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ALBANY INSTITUTE.

A
SYSTEM OF MINERALOGY:
INCLUDING AN EXTENDED
TREATISE ON CRYSTALLOGRAPHY:
WITH AN APPENDIX, CONTAINING THE
APPLICATION OF MATHEMATICS
TO
CRYSTALLOGRAPHIC INVESTIGATION,
AND A
MINERALOGICAL BIBLIOGRAPHY.

WITH TWO HUNDRED AND FIFTY WOOD CUTS, AND FOUR COPPER PLATES, CONTAINING ONE HUNDRED AND FIFTY ADDITIONAL FIGURES.

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"Hæc studia nobiscum peregrinantur, rusticantur."

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PREFACE.

The tardy progress of Mineralogy in this country, and in England, presents a striking contrast with its rapid advancement in continental Europe. The new systems of classification, and the various methods of crystallographic examination, which every passing year has there produced, evince alike the activity and penetration of its zealous cultivators. The principles of Crystallography, as developed by the Abbé HAUY, the memorable founder of this Science, were immediately, on their publication, hailed as new light, and for a time, his methods of calculation were expounded by different authors, and his crystallographic nomenclature and notation very generally received. But the more elegant and much simplified systems, soon after developed by the German philosophers, and, at the present time universally employed by them in all crystallographic investigations, are, to a great extent, unknown in the English tongue; and wholly so, if we except the valuable translation of MOHS by HAIDINGER, and the various memoirs of unusual merit by the latter, and also by the Rev. WM. WHEWELL. In addition to these improvements, we are also indebted to the illustrious MOHS for a Natural Arrangement of the Mineral Species, by means of which Mineralogy has been elevated to its proper rank among the Natural Sciences. The hope of filling up, in some degree, the existing blank in these departments of American Mineralogical Science, and of contributing to its advancement, by combining the various excellencies from the most valuable works on this Science, has induced the author to offer the following Treatise to the American public.

The classification of the mineral species, which is here adopted, is strictly a *Natural* Arrangement. The superiority of this method is exhibited in the body of the work, and in connection with the remarks on Chemical Classifications, in Appendix B. Although founded by MOHS on the external characters of minerals, it exhibits, in a considerable degree, the chemical relations of the species; and those who are accustomed to prefer a chemical arrangement, will probably perceive that, in addition to such qualities as appear to recommend the chemical method, it possesses other advantages not less important.

The changes which have been made in the nomenclature of minerals appear to be demanded by the state of the Science. The present names, excepting those proposed by MOHS, are utterly devoid of system, unless we may consider such the addition of the syllable *ite* to words of various languages; and even this glimmering of system has been capriciously infringed by a French mineralogist of much celebrity;—they seldom designate any quality or character peculiar to the mineral; neither do they exhibit any of the general relations of the species, by which the mind may, at a glance, discover their natural associations, and be assisted in obtaining a comprehensive view of the Science. On the contrary, they are wholly independent, and often worse than unmeaning, appellatives, and are only tolerable in a very unadvanced state of the Science. As a necessary consequence of this looseness of nomenclature, most of the species are embarrassed with a large number of synonyms, a fertile source of confusion and difficulty.

As a remedy for this undesirable state of things, a system of nomenclature, constructed on the plan so advantageously pursued in Botany and Zoology, was proposed by the author in the fourth volume of the Annals of the New York Lyceum. The necessity for something of the kind is very apparent, and the author trusts that it will not be considered a needless innovation. The progress of knowledge is much retarded by a reluctance to change with the advancement of Science. "In general," to use the words of one entitled to speak with authority, "nothing which tends to render any of the parts of a science stationary, can be beneficial to it; the whole should together advance as discovery and information multiply." (Berzelius: Traité de Chim. t. I.)

The mutual dependence of the forms of crystals and their optical properties, might have afforded an additional method for determining the system of crystallization of minerals. For our knowledge of this subject, we are principally indebted to Sir DAVID BREWSTER, for a full and systematic exposition of which, from his able pen, Science has long and anxiously waited. His various articles in the Scientific Journals, and in his separate publications, encourage us to expect that in a more advanced stage of Optical Science, this may prove one of the most important and available aids to the crystallographer. In the chapter on Double Refraction, the connection of refraction with crystalline form is briefly stated.

The curious discoveries of SAVART, concerning the acoustical properties of crystals, promise another means for ascertaining the crystalline form. This philosopher has been enabled to infer the primary planes of a crystal of quartz from the sound and acoustical figures produced by their vibration. Much farther investigation will, however, be required before this subject will be sufficiently systematized to become practically useful.

It will be observed that the method of lettering crystals is somewhat peculiar. The custom of indiscriminately distributing letters on the planes of crystals, secures no advantage beyond that of merely designating these planes. The method employed affords important aid in determining the *situation* of planes. Its analogy to NAUMANN's method of notation, explained in the Appendix on Mathematical Crystallography, is manifest without particular illustration. The system proposed by the author, in the twenty-eighth volume of SILLIMAN's American Journal of Science, is relinquished.

In the classifications for the determination of species, a tabular arrangement has been preferred. A similar method was employed as early as 1771, by Dr. JOHN HILL, who, in his work on Fossils, arranged the minerals then known, in tables, exhibiting in separate columns their specific characters, "under the heads of Form, Hardness, Weight, Surface, Colour, and Qualities, as distinguished by the taste, smell, or touch." In the construction of the arrangements adopted, I have not been averse to the introduction of any character that could aid the student. With the assistance both of the blowpipe and of acids, the difficulties are sufficiently great; and by rejecting these aids, we deprive ourselves of what are frequently the most convenient, and often the only methods that can be employed.

The treatise on the calculation of the dimensions and angles of crystals, from the masterly work of NAUMANN, is placed in the Appendix; not on account of its inferior importance, but simply because of its somewhat unattractive appearance. The value of crystallographic calculations in the examination of the mineral species, and the importance they will probably be discovered to possess, in elucidating the principles of isomorphism and the relations of crystalline form and chemical composition, entitle this subject to high estimation, both with the chemist and mineralogist. The only preliminary knowledge necessary, is an acquaintance with the principles of algebra and trigonometry: with these, the treatise on analytical geometry is readily mastered, and the application of the same, in the succeeding sections, becomes easily intelligible. It may demand of the student patient and persevering study; but the advantage of the knowledge, when obtained, and the increased interest the science will derive from these elegant and interesting developments of the structure of crystals, will amply reward his toil.

In preparing the descriptive part of this work, I have freely availed myself of the labors of the best authors; and more especially the learned Treatises of MOHS and of ROBERT ALLAN. The recent copious "System of Mineralogy and Geology," by THOMAS THOMSON, has also afforded me much assistance. Very many of the analyses herein given, and the references therewith connected, are derived from that elaborate work. For most of the observations on the names of the minerals known to the ancients, I am under obligation to the "Ancient Mineralogy" of Prof. N. F. MOORE. The notices of the localities of American minerals, have been principally drawn from the late Treatise by Prof. SHEPARD, a work which has tended much to advance and elevate American mineralogical science. Occasional reference has also been made to the valuable works of CLEAVELAND and EMMONS. The various scientific Journals of the country have also been consulted, and especially that extensive repository of the scientific labors of our countrymen, SILLIMAN'S American Journal of Science.

A few minerals here introduced, have not been provided with systematic names. It appeared advisable to forbear naming them, until their specific characters are more fully established.

The Catalogue of foreign works on Mineralogy comprises the fathers of the Science, with a selection of the more important treatises of modern times. The American catalogue is intended to record not only all separate works, but likewise all mineralogical articles of any importance found in the transactions of learned societies, in scientific journals, and other periodicals. This is doubtless incomplete; nor is it possible, without long continued labor, to render it perfect. I trust that the difficulties attendant on its execution, will be a sufficient apology for any omissions which may be detected.

My grateful acknowledgments are due to Prof. SILLIMAN, who, with his accustomed liberality, has granted the freest access to his extensive library. I have, by this means, been enabled to examine at an early date most of the important European journals, and thus to include the latest discoveries.

I would also acknowledge the constant kind attentions of my much esteemed friend, Mr. EDWARD C. HERRICK, to whom I am indebted for many valuable suggestions.

NEW HAVEN, May 1st, 1837.

CORRECTION.—Since the printing of this work I have been informed by Dr. PERCIVAL, who, with Prof. SHEPARD, has lately been engaged in the Geological Survey of this State, that the supposed mountain of Saussurite, at Canaan, (see p. 288,) is a low ridge of limestone, containing beds of *white pyroxene*.

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INTRODUCTION.

COMPARATIVE VIEW OF THE NATURAL SCIENCES.

1. The productions of our globe naturally distribute themselves into three grand kingdoms, the Animal, the Vegetable, and the Mineral; and our knowledge of their external characters, is comprised in the Natural Sciences, Zoology, Botany, and Mineralogy.

The two first kingdoms include all beings possessed of vitality: beings which increase by an assimilation of nutritive substances, taken internally; which arrive at maturity by a series of successive developments; whose parts are mutually dependent, and cannot be separated without destroying the perfection of the individual; which, after a certain period, lose the capability of continuing the usual functions of life, and consequently die. The powers of vitality being no longer present to counteract decomposition, death is soon followed by a complete destruction of the original living being.

The Mineral kingdom, on the contrary, contains those natural objects that are not possessed of life: objects which increase by accretion merely, or an external addition of particles, unaltered by any powers of assimilation in the object; which are equally perfect in the embryo state, or at the earliest commencement of their formation, and in the enlarged individual; whose individuality is not destroyed by a separation of parts; whose formation is originally the result of chemical attraction, and, consequently, they are not, from their nature, necessarily liable to decomposition.

Mineralogy comprises the two distinct, though closely allied sciences, *Mineralogy* proper, and *Geology*. The former considers minerals as independent bodies; the latter, in their dependent relations, constituting soils and various rocks. It is the object of Mineralogy to describe the individual qualities of the several mineral species, while Geology treats of them only as associated in the structure of the earth.

In the following treatise, we shall be occupied only with the former of these sciences. Mineralogy and Geology, however, are so intimately related, that it will be impossible to be complete in our accounts of minerals, without making some Geological observations.

Previous to entering on this subject, it will be necessary to understand what is a mineral. The word Mineral is applied to all *inorganic* natural objects, whether *solid*, *liquid*, or *gaseous*. This signification is much extended beyond its original limits. Some term, however, was required, applicable to *all* inorganic bodies, and the extension of this word has been preferred to the coinage of a new one.

MINERALOGY: SUBDIVISIONS OF THE SUBJECT ADOPTED IN THE FOLLOWING TREATISE.

2. There exists in organic matter a power called crystallization, or crystallogenic attraction, by the action of which, minerals receive their peculiar forms. This power is analogous to vitality in the animal and vegetable kingdoms, whence arises the variety of structure in plants and animals. Under the head of Crystallology, or *the Science of the Structure of Minerals*, this subject will occupy Part I. of the following treatise. *Crystallology* includes the two sections; 1. Crystallography, or descriptions of the crystalline forms of minerals; 2. Crystallogeny, the formation and internal structure of crystals.

Having concluded the account of the *structure of minerals*, we next consider their properties.

First, those depending on the *transmission and reflection of Light*, on *Electricity*, *Magnetism*, *Gravity*, *Cohesion*, and also, their relations to the senses of *taste* and *smell*, or their *Taste* and *Odor*. These may be termed the *Physical Properties of Minerals*, and will constitute the subject of Part II.

Second, those properties ascertained by the action of chemical reagents and the blowpipe. These, the *Chemical Properties of Minerals*,* will be considered in Part III.

Taxonomy, or the subjects of *Classification* and *Nomenclature*, will be comprised in Part IV.

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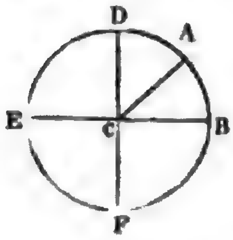
* These characters require for their determination a destruction of the individual, and have therefore, been rejected by many distinguished mineralogists, who would confine themselves to *Natural History*, or external characters.

After much examination, with prejudices at the time in favor of the above views, I am fully convinced, that these alone are insufficient for the determination of many mineral species, often so Protean in several of their characters. One instance of this difficulty, from among several which now occur to me, is the discrimination between carbonate of strontian, carbonate of barytes, and sulphate of strontian, when their crystalline form is not distinct, and the specimen is so situated, that the specific gravity cannot be determined. Each of these minerals may have a white color, the same hardness, similar lustre; and, in general, all their describable physical properties are the same. It is allowed, that the experienced mineralogist might not perceive any difficulty; but what means has the tyro in the science of distinguishing these three species? None but chemical. A drop of acid decides which is the sul-

Parts V. and VI. will include the classifications of the mineral species, according to the methods pointed out in the preceding sections; Part V. the artificial classifications for the determination of the names of species, under the general head of *Determinative Mineralogy*; Part VI. the natural classification, with full descriptions of the species, under the title of *Descriptive Mineralogy*.

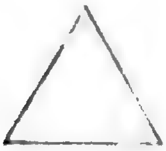
3. In the progress of the treatise, a few of the simple definitions in geometry will be required, which may be here explained.



a. A *plane angle* is the divergence of two straight lines from a given point; as the angle ACB formed by the meeting of AC and BC. If a circle be described, with the angular point C as the centre, and its circumference, BFEDA, be divided into 360 parts, the number of these parts, included between the two lines forming the angle, will be the number of degrees contained by the angle; that is, if 40 of these parts are included between A and B, the angle ACB equals 40°. DF being perpendicular to EB, these lines divide the circumference into four equal parts, and, consequently, the angle DCB equals 360° ÷ 4 equals 90°. This is termed a *right* angle. It will be observed, that the size of the angle is independent of the lines DC and BC. An angle of any other number of degrees is termed an oblique angle, and if it is less than a right angle, as ACB, it is an *acute* angle, if greater, as ACE, an *obtuse* angle.

b. The angles ACE and ACB together equal 180°, because the arc BAE, which measures them, is half the circumference. If ACB, therefore, is known, we may find ACE by subtracting ACB from 180°.

1



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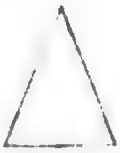

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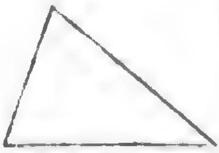

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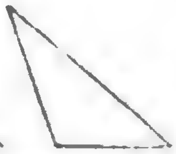

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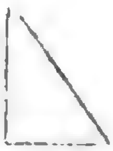

c. A *triangle* is a figure bounded by three straight lines. If the sides are equal, the triangle is *equilateral*, (1): if two only are equal, it is *isosceles*, (2): if all are unequal, *scalene*, (3, 4): when the angles are all acute, it is termed an *acute angled triangle*, (3): when there is one obtuse angle, an *obtuse angled triangle*, (4).

If one angle of a triangle is right, it is termed a *right angled triangle*, (5.)

d. The sum of the angles in a triangle, equals 180°.

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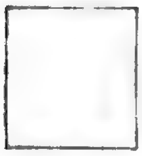
phate, and the application of the blowpipe, by the deep red color of the flame, determines which of the two carbonates contains strontian. Chemical tests must, therefore, be admitted, as a matter of necessity, among the means of distinguishing the mineral species.

6



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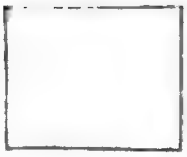

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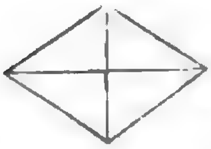

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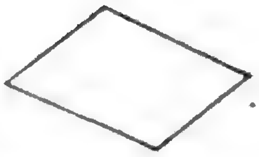

e. A *square* is bounded by four equal sides, meeting at right angles, (6.)

f. A *rectangle* differs from a square in having only its opposite sides equal, (7.)

g. A *rhomb* is an oblique angled plane figure, contained under equal sides, the opposites of which are parallel, (8.)

h. A *rhomboid* differs from a rhomb, in having only its opposite sides equal, (9.)

i. A *diagonal* of either of the above figures is a line connecting the opposite angles; in fig. 8, one is called the longer, the other the shorter diagonal.

k. The four angles, in either of the above four sided figures, equal 360°.

l. A *prism* is a solid, bounded by plane faces, two of which are parallel and are called the *bases*, (fig. 50, Pl. I.) and the other faces M, M, the *lateral* planes. These prisms either stand erect on their bases, the lateral planes being perpendicular to the basal, or they are inclined, the lateral planes not being perpendicular to the basal. The first are called *right prisms*, the second *oblique prisms*.

m. *Octahedrons* are bounded by eight triangular faces, (figs. 4, 52, Pl. I.)

n. *Dodecahedrons* are contained under twelve faces, (fig. 7, Pl. I., and fig. 124, Pl. II.)

o. An *interfacial* angle, is the angle contained by two faces of a crystal, and measures their inclination. It is designated by the letters on the faces which form the angle, as the interfacial angle M : T, for the angle of inclination of plane M on plane T.

p. A *solid angle* is formed by the meeting of three or more planes or faces of a crystal.

r. Any lines in these solids, connecting similar parts, diagonally opposite, may be called *axes;* for example, the lines connecting the vertices of opposite solid angles, the centres of opposite edges, or the centres of opposite faces. The particular axes which have been assumed for the purposes of crystallography, will be hereafter stated.

s. *Similar faces* have their corresponding angles equal.

t. *Similar edges* are those formed by the inclination of similar faces equally inclined.

u. *Similar solid angles* are formed by the meeting of the same number of plane angles, equal each to each, and belonging to planes respectively similar.

MINERALOGY.

PART I.

CRYSTALLOLOGY,

OR, THE SCIENCE OF THE STRUCTURE OF MINERALS.

SECTION I.

CRYSTALLOGRAPHY.

4. *A crystal is an inorganic solid, bounded by plane surfaces symmetrically arranged, and possessing a homogeneous structure.*

In its original signification, this term applied only to crystals of quartz, which the ancient philosophers believed to be *water* congealed by a very intense cold. Hence the term, from κρυσταλλος, ice.* It now includes all those regular solids that owe their formation to the same kind of attraction that produced the κρυσταλλος of the ancients, or which, like that, possess a regular form, whatever may be the color or the degree of transparency or opacity.

5. The varieties of crystalline forms, occurring in the mineral kingdom, are exceedingly numerous. They are all derivable, however, from a few simple solids, which are denominated the *primary forms*. The derivative forms are termed *secondary forms* of these primary solids.

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* *Diodorus* II. 52, p. 163, Wess.—τοὺς γαρ κρυστάλλους λίθους ἔχειν την σύστασιν ἐξ ὕδατος καθαροῦ παγέντος, οὐχ ὑπὸ ψύχους, ἀλλ' ὑπὸ θείου πυρος δυναμεως.

Seneca. Quæst. Nat. III. 25: Unde autem fiat ejusmodi lapis apud Græcos ex ipso nomine apparet. Κρυσταλλον enim appellant æque hunc perlucidum lapidem quam illam glaciem ex qua fieri lapis creditur. Aqua enim cœlestis minimum in se terreni habens, quum induruit longioris frigoris pertinacia spissatur magis ac magis donec omni aëre excluso in se tota compressa est, et humor qui fuerat, lapis effectus est.

Plinius, Hist. Nat. XXXVII. 2: Murrhina—humorem putant sub terra calore densari. Contraria huic causa crystallum facit, gelu vehementiore concreto.

A cube, fig. 1, is one of the primaries; the same with its angles removed, fig. 2, is a secondary to the cube, and the planes a, a, on the angles, are called the secondary planes. The cube, with its edges removed, fig. 5, is another secondary to this solid; and as above, the planes e are secondary planes, and P, the remaining parts of the primary.

The occurrence of these forms is governed by two important laws, on which the value of the science of Crystallography to the mineralogist mainly depends: 1. that the same mineral presents universally the same primary form, and always, when crystallized, exhibits either this primary or some secondary to it; 2. that a particular primary is invariable in its interfacial angles, and the interfacial angles of its similar secondary planes.

Thus galena always crystallizes in cubes, or secondaries to this primary; calcareous spar, in oblique prisms of constant angles, or some modification of this form, produced by a simple law, which will be given in a future section.

We are thus enabled, by a determination of one or two angles, to arrive with certainty at the names of most of the mineral species, when they occur in regular crystals.

CHAPTER I.

PRIMARY FORMS.

COMPARATIVE VIEW OF THE PRIMARY FORMS.

6. The primary solids are fourteen in number, and may be distributed as follows: 1. Prisms; 2. Octahedrons; 3. Dodecahedrons.

The prisms have either a *six-sided* base, or a *four-sided* base. Of the former there is but one instance in the mineral kingdom. Its name, derived from the nature of the base, a regular hexagon, is the *Hexagonal Prism*, fig. 114.

The prisms with tetragonal bases are either right or oblique, (§ 3, *l*.) and are named according to their bases.

1. *Right Prisms.*

Base a square; lateral planes equal to basal.	*Cube*, (fig. 1.)
Base a square; lateral planes not equal to basal.	*Right Square Prism*, (fig. 59.)
Base a rectangle, (§ 5, *e*.)	*Rt. Rectangular Pm.* (fig. 69.)
Base a rhomb, (§ 5, *e*.)	*Rt. Rhombic Pm.* (fig. 72.)
Base a rhomboid, (§ 5, *e*.)	*Rt. Rhomboidal Pm.* (fig. 87.)

2. *Oblique Prisms.*

Base a rhomb; lateral planes equal to basal.	*Rhombohedron*,[*] (fig. 107, 108.)
Base a rhomb; lateral planes not equal to basal.	*Ob. Rhombic Pm.* (fig. 91.)
Base a rectangle.	*Ob. Rectangular Pm.*
Base a rhomboid.	*Ob. Rhomboidal Pm.* (fig. 103.)

The octahedrons are also named from their bases. The base of the octahedron is a section passing through four angles.

Base a square; faces equilateral triangles.	*Regular Oct.* (fig. 4.)
Base a square; faces isosceles triangles.	*Square Oct.* (fig. 52.)
Base a rectangle.	*Rectangular Oct.* (fig. 81.)
Base a rhomb.	*Rhombic Oct.* (fig. 76.)

The square octahedron has only one square section, (fig. 52;) those through the other angles are rhombs. In the same manner the rectangular octahedron has but one rectangular section; its others are rhombs. All the sections of the rhombic octahedron are rhombic.

There is but one primary dodecahedron. This is contained under rhombic faces, and is called the *Rhombic Dodecahedron*, (fig. 7.)

7. A more comprehensive view of the relations of the primary forms is given in the following table.

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[*] This solid is usually termed the *rhomboid*. This name, however, is the ordinary appellation of a plane figure, (§ 3, 9,) and is therefore improperly applied to a solid; and particulary to one, none of whose faces are rhomboids.

PRIMARY FORMS.

- PRISMS
  - base hexagonal—*Hexagonal Prism.*
  - base tetragonal
    - right
      - lateral planes equal to basal—*Cube.*
      - lateral planes unequal to basal
        - base a square—***Right Square Prism.***
        - base a rectangle—***Right Rectangular Prism.***
        - base a rhomb—***Right Rhombic Prism.***
        - base a rhomboid—***Right Rhomboidal Prism.***
    - oblique
      - lateral planes equal to basal—***Rhombohedron.***
      - lateral planes unequal to basal
        - base a rhomb—***Oblique Rhombic Prism.***
        - base a rectangle—***Oblique Rectangular Prism.***
        - base a rhomboid—***Oblique Rhomboidal Prism.***
- OCTAHEDRONS
  - faces equilateral—*Regular Octahedron.*
  - faces not equilateral
    - base a square—***Square Octahedron.***
    - base a rectangle—***Rectangular Octahedron.***
    - base a rhomb—***Rhombic Octahedron.***
- DODECAHEDRONS.—***Rhombic Dodecahedron.***

DESCRIPTIONS OF THE PRIMARIES AND THEIR MUTUAL RELATIONS.[*]

8. *Cube—Regular Octahedron—Rhombic Dodecahedron.*

a. Cube, (fig. 1.) The faces of the cube are equal, and their plane angles right. Its eight angles and twelve edges are therefore similar. Its eight angles are represented as truncated in fig. 2; the removal of the angles is continued still farther in fig. 3, and to the obliteration of the primary planes in fig. 4, which is an octahedron. The octahedron may therefore proceed from the cube, by replacing its solid angles, which are in number equal to the faces of the octahedron.[†]

Fig. 5 is a cube, with its edges truncated. This process is continued in fig. 6, and completed in fig. 7, which is the rhombic dodecahedron. This solid, therefore, may be cut from a cube, by removing its edges in the above manner.

b. Octahedron, (fig. 4.) The regular octahedron has six solid angles and twelve edges, all of which are similar. Its plane angles are 60°, and its interfacial 109° 28′. 16″. Its passage into the cube is observed in figs. 3, 2, 1, where it is seen to proceed from a truncation of the solid angles, which are six in number. Its edges are truncated in figs. 9 and 8, and the resulting form, represented in fig. 7, which is again the rhombic dodecahedron. Its edges equal in number the faces of this solid.

c. Rhombic Dodecahedron. The rhombic dodecahedron has twenty-four similar edges. The faces being rhombs, and consequently, two of the plane angles obtuse, and two acute, the solid angles are of two kinds; six are formed of four acute plane angles, and are called the *acute* solid angles; eight are composed of three obtuse, and are called the *obtuse* solid angles. The former correspond to the number of faces of the cube, and yield by their truncation this solid, (figs. 6, 5, 1;) the latter to those of the octahedron, and truncated, afford an octahedron. (figs. 8, 9, 4.) The plane angles of the dodecahedron are 109° 28′ 16″, and 70° 31′ 44″: its interfacial angles equal 120°.

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[*] In the following remarks on this subject, a few technical terms are employed, to avoid circumlocutions. They may be explained as follows:

Replacement. An edge or angle is *replaced*, when cut off by one or more secondary planes.

Truncation. An edge or angle is *truncated*, when the replacing plane is equally inclined to the adjacent faces, (fig. 2, a, and 5, e.)

Bevelment. An edge is *beveled*, when replaced by two planes, which are respectively inclined at equal angles to the adjacent faces, (fig. 10, e′.) It may be applied to an angle when it is replaced by three planes, each inclined at the same angle, to its adjacent face, (fig. 14.) Truncation and bevelment can only occur on edges or angles formed by the meeting of equal planes.

Planes on an edge, have their intersections with the adjoining faces, parallel to the edge. The intersections of e′ e′, fig. 10, are parallel to the original edge.

Planes on an angle, intersect the basal face parallel to its diagonal. The intersection of a with the basal P, (fig. 2, or 51,) is parallel to the diagonal of P.

Intermediary planes, intersect the basal faces parallel neither to the diagonal nor to an edge, but have an intermediary situation. Such are planes o, o, (fig. 24 and 58.)

[†] The facts stated in this and the following paragraphs, would be more thoroughly impressed on the mind of the student, if he should perform the dissections here described, with some convenient material, as chalk, raw potatoes, wax, or wood. By thus actually deriving one form from another, the mutual relations of the primary forms will be easily understood. Chalk is, for many reasons, preferable for this purpose. When the models are finished, their surfaces may be rendered quite hard, by covering them with a solution of gum or varnish.

9. *Right Square Prism and Square Octahedron.*

a. Right Square Prism. All the basal edges of the right square prism are equal, but unequal to the lateral. There are, therefore, two kinds of edges, eight basal and four lateral. The eight solid angles are each composed of three right angles, and are therefore similar. A replacement of the eight solid angles gives rise to a right square octahedron, (figs. 51, 52,) in a manner similar to the derivation of a regular octahedron from a cube.

b. Square Octahedron. The edges of the square base of this octahedron are termed the *basal* edges, and are four in number. The other edges have been variously designated, the *pyramidal* and *terminal.* The latter term will hereafter be employed. The same remark applies to the remaining octahedrons. The truncation of the six solid angles of this solid affords the right square prism.

10. *Right Rectangular Prism—Right Rhombic Prism—Rectangular Octahedron, and Rhombic Octahedron.*

a. Right Rectangular Prism, (fig. 69.) In the right rectangular prism, there are two kinds of basal edges, each of which is unlike the lateral. It has, therefore, three kinds of edges, four of each kind. Its faces being unequal, either one might be considered the base; it is, however, usual, in figuring crystals of this kind, to assume the smallest for the base, and to make the smaller of the lateral the right hand plane. Its eight angles are similar.

A replacement of four similar lateral edges is represented in fig. 70, and also a deeper replacement in fig. 71. The completed form thus obtained is a *right rhombic prism,* (fig. 72.) Conversely, the replacement of the lateral edges of the right rhombic prism affords a right rectangular prism, (figs. 71, 70, 69.)

b. Right Rhombic Prism. This prism is in position when on its rhombic base, with an obtuse edge towards the observer. Its basal edges are similar. Its lateral are of two kinds; *two obtuse* and *two acute.* Its angles are also of two kinds; *four obtuse* and *four acute.*

Fig. 73 represents a rhombic prism, situated within a rectangular, and elucidates the fact above stated, that the faces of the former proceed from a replacement of the edges of the latter. From it is also obvious, that the solid angles of the rhombic prism correspond to the basal edges of the rectangular; and conversely, the solid angles of the rectangular prism to the basal edges of the rhombic. If, as the solids are situated in the figure, we replace the solid angles of the rhombic prism, the same replaces the basal edges of the rectangular; and if we replace the basal edges of the former, we, at the same time, replace the angles of the latter.

c. It will now be understood, that a *rectangular* octahedron may be formed by replacing the basal *edges* of the rectangular prism, or the solid *angles* of the rhombic, (figs. 80, 81, and 82, 81;) also, that the *rhombic* octahedron may be formed by replacing the eight *angles* of the rectangular prism, or the eight basal *edges* of the rhombic, (figs. 74, 76, and 75, 76.)

11. *Right Rhomboidal Prism and Oblique Rhombic Prism.*

a. Right Rhomboidal Prism, (fig. 87.) The right rhomboidal prism has a rhomboidal base and two unequal rectangular lateral planes. Placed upon its rhomboidal base, it has two obtuse, ē, ē, and two acute, ĕ, ĕ, lateral edges, and two kinds of basal edges. Its solid angles are of two kinds, four obtuse and four acute.

To exhibit the relation of this prism to the oblique rhombic prism, it is more convenient to make one of its rectangular faces its base, (fig. 88,) and the rhombic plane P a lateral plane. ē is then an obtuse edge, and the prism thus situated is inclined backward. If now the lateral edges *e, e, e,* are replaced, a rhombic prism will be produced, (figs. 90, 91,) which, on account of the inclined situation of the rhomboidal prism, will be an *oblique* rhombic. (Fig. 89, shows the same planes, *e*, on the rhomboidal prism, situated on its *rhomboidal* base.) Conversely, a truncation of the lateral edges of the oblique rhombic prism, (fig. 89 or 90,) gives rise to the right rhomboidal prism. In the present position of this primary, it might be considered an oblique rectangular prism. The oblique rectangular prism differs from this, however, in being oblique over an angle, that is, in the direction of *a c* instead of *a b* or *d c*, fig. 88.

b. Oblique Rhombic Prism, (fig. 91.) The oblique rhombic prism has two obtuse and two acute lateral edges; four obtuse basal, ē, ē, and their opposites; four acute basal, ĕ, ĕ, and their opposites, ĕ, ĕ.

Octahedrons may be obtained from these solids; but they would be oblique. Fig. 99, represents one formed by a replacement of its solid angles, or the terminal edges of the right rhomboidal prism. They do not occur in nature.

12. *Oblique Rectangular Prism.*

This form does not occur in the mineral kingdom. The remarks concerning the oblique rhomboidal prism, may be considered as applying also to this solid. It has been observed in some artificial salts.

13. *Oblique Rhomboidal Prism*, (fig. 103.)

The oblique rhomboidal prism has no similar parts except those which are diagonally opposite. There are, therefore, six kinds of edges, ē·, ·ē, ĕ·, ·ĕ, basal, and *ē*, *ĕ*, lateral, (fig. 103,) and four kinds of angles, (ā, ă, *a*·, ·*a*.)

14. *Rhombohedron and Hexagonal Prism.*

a. *Rhombohedron.* The rhombohedron has two kinds of solid angles. Two of these angles, a, a, (figs. 107, 108,) are composed either of three obtuse, (fig. 107,) or three acute, (fig. 108,) plane angles, and the rhombohedron is called *obtuse* or *acute*, according as these angles are *obtuse* or *acute*. These angles are called the *vertical* solid angles. The rhombohedron is in position when they are situated, the one vertically above the other, as in the above figures. The other six angles, (*a*, figs. 107, 108,) are similar, and are called the lateral angles. They are composed, either of two obtuse and one acute, or two acute and one obtuse plane angles. The edges are also of two kinds. Those which meet at the apices of the vertical solid angles, e, (figs. 107 and 108,) are of one kind, (obtuse in fig. 107, acute in 108,) and are called the terminal edges. The remaining six, (*e*,) are the lateral edges. It will be observed, that when the rhombohedron is in position, that is, when the line between the two vertical angles is perpendicular, the six lateral edges and six solid angles are symmetrically arranged about this line. We may, therefore, conclude, that the replacement of the angles or the edges, by planes parallel to this line, will each produce hexagonal prisms. This may also be observed in figs. 111, 112, and figs. 109, 110. Fig. 114, is the completed hexagonal prism; the terminal plane P, results from a truncation of the terminal angle of the rhombohedron, (fig. 113.)

b. To obtain a rhombohedron from a hexagonal prism, it is necessary to replace, *similarly*, the alternate edges at one end, (R, R, R, fig. 114,) and those alternate with these at the other, (R, &c.); or the alternate angles at one end, and those again alternate, at the other. Compare figs. 112 and 110, with 114. The situation of R, R, fig. 112, corresponds to the edges, R, R, fig. 109, and R, R, fig. 110, to the alternate angles.

The diagonal of a face connecting two lateral angles of the rhombohedron, is called a *horizontal* diagonal; that connecting a vertical with a lateral, is termed an *inclined* diagonal.

15. Each of the oblique prisms contains two solid angles, which are analogous to the vertical in the rhombohedron; that is, are composed either of three obtuse, or three acute plane angles. These angles have been called the *dominant solid angles*. If the plane angles of the *dominant solid angle* are obtuse, the prism is oblique from an obtuse edge, and is termed an obtuse prism; if acute, the prism is oblique from an acute edge, and is termed an acute prism.

CRYSTALLOGRAPHIC AXES, AND CLASSIFICATION OF THE PRIMARY FORMS.

16. In the preceding section it has probably been observed, that as several of the primary forms may be derivatives from one an-

other, they are naturally distributed into several classes, each to contain all those primaries which are capable of mutual derivation. Thus, the cube, octahedron, and dodecahedron, may be united in one class; the right square prism and square octahedron, in a second; the right rectangular and right rhombic prisms, and the rectangular and rhombic octahedrons, in a third; the right rhomboidal and oblique rhombic, in a fourth; the oblique rectangular, in a fifth; the oblique rhomboidal, in a sixth; and the rhombohedron and hexagonal prism, in a seventh. The same classification will follow, from the axes of these solids which we are now to consider.

17. *Cube, Octahedron, Dodecahedron,* (figs. 1, 4, 7.) The axes of the cube, are lines connecting the centres of its opposite faces. They are consequently *equal, and intersect at right angles.* If we derive an octahedron from the cube, after the manner described in § 8, *a*, the centres of the faces of the cube are the last of the primary faces that vanish. The central point is, therefore, the angular point of the octahedral angles, and, therefore, the axes of the cube which connect these points, connect the solid angles of the octahedron. The same lines are assumed as the crystallographic axes of the octahedron, and similar to those of the cube, *they are equal, and intersect at right angles.* If a dodecahedron be derived from a cube, as in § 8, *a*, it will appear in the same manner, that the axes of the cube will connect the *acute* solid angles, whose angular points are the centres of the faces of the cube. These are also the axes of the dodecahedron.

The *cube, octahedron,* and *dodecahedron,* have, therefore, similar and equal axes. They are hence naturally comprised in the same class. To this class may be applied the name MONOMETRICA, from μόνος, *one*, and μέτρον, *measure*, in allusion to the equality of the axes.*

18. *Right Square Prism, and Square Octahedron,* (figs. 50, 52.) The crystallographic axes of this prism, connect the centres of its opposite faces. The two *lateral* axes are equal, but unequal to the other, which is called the *vertical* axis. It is also termed the *varying* axis, since different right square prisms differ in the lengths of this axis. As in the regular octahedron, and for the same reason, the axes of the square octahedron connect the opposite solid angles. The two lateral are equal, but unequal to the vertical. To this class we give the name DIMETRICA, from δις, *twofold*, and μέτρον, *measure*, alluding to the two kinds of axes.†

19. *Right Rectangular Prism, Right Rhombic Prism, Rectangular Octahedron, and Rhombic Octahedron,* (figs. 69, 72, 81,

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* Synonyms. *Tesseral* or *Tessular System* of Werner and Mohs; *Isometric* of Hausmann.

† *Tetragonal* System of Naumann; *Pyramidal* of Mohs; *Monodimetric* of Hausmann.

76.) In the right rectangular prism, the axes connect the centres of the opposite faces, and, from the nature of the solid, are ***unequal*** to one another. Their intersections are rectangular. If a rhombic prism is formed from a right rectangular, by the replacement of its lateral edges, the lateral axes of the rectangular prism, will connect the centres of the opposite edges (fig. 71,) of the rhombic. These, therefore, are the lateral axes of the latter prism. The vertical axis joins the centres of the opposite bases in the same manner as in the rectangular. In a rectangular octahedron, derived from a right rectangular prism, the lateral axes unite the centres of the opposite edges, (figs. 80, 81.) The rhombic octahedron, formed on the angles of the same prism, contains as axes, lines connecting the opposite angles, similar to the regular octahedron, (figs. 75 and 76.)

These four solids, capable of mutual derivation, and containing three unequal rectangular axes, may form the class Trimetrica,* from τϱις, *threefold*, and μέτϱον, *measure*, as there are three dissimilar axes.

20. *Right Rhomboidal Prism, and Oblique Rhombic Prism,* (figs. 88, or 87, and 91.) In the right rhomboidal prism, the lines which are assumed as the crystallographic axes connect the centres of the opposite faces. From an examination of their intersections, it appears that two of the axes cross at right angles, while a third is inclined to one of the other two at an oblique angle. Out of three angles, formed by the intersections of the axes, two are right and one oblique. This may be rendered obvious, by a reference to the inclinations of the planes to which the axes are parallel. The interfacial angle, (fig. 84, or 85,) M : T is an oblique angle, while P : T=90°. P : M=90°, that is, out of the three angles, two are *right* and one *oblique*. From fig. 82, it is apparent, that the oblique rhombic prism, derived from this solid in the manner described in § 11, will have two lateral axes connecting the centres of the opposite lateral edges. The axes have the same inclinations as in the right rhomboidal prism. There being but one oblique angle among the three just noticed, this class may be designated Monoclinata, μόνος, *one*, and κλινω, *to incline.*†

21. *Oblique Rectangular Prism,* (similar to fig. 103.) The axes of this solid unite the centres of its opposite faces. Of three intersections, two are oblique and one right. This, therefore, forms the class Diclinata, δις, *twofold*, and κλινω, *to incline.* ‡

22. *Oblique Rhomboidal Prism,* (fig. 103.) The axes which connect the centres of the faces, form three oblique intersections.

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* *Rhombic System* and *Anisometric System* of Naumann; *Prismatic* of Mohs; *Trimetric* of Hausmann.

† *Monoclinohedral* of Naumann; *Hemi-prismatic* of Mohs; *Hemi-rhombic* of Breithaupt.

‡ *Diclinohedral* of Naumann.

It, therefore, forms the class TRICLINATA, τρεις, *threefold*, and κλινω, *to incline.*[*]

23. *Rhombohedron and Hexagonal Prism*, (figs. 107, 108, and 114.) The vertical axis in the rhombohedron, connects the vertical solid angles. The lateral are three in number, and unite the centres of the opposite lateral edges. And since the lateral edges are symmetrically arranged about the vertical axis, they will intersect at equal angles; and as, by their intersections, they therefore divide the plane, about the point of intersection, into six equal parts, the angles of intersection must be one-sixth of 360°, or 60°. These axes are also at right angles with the vertical. From the derivation of the hexagonal prism from the rhombohedron, we readily deduce that it contains a vertical axis, connecting the centres of its bases, and three lateral axes uniting the centres of the opposite lateral edges or lateral faces, according as the hexagonal prism is formed on the lateral angles or edges of the rhombohedron. These axes also intersect at angles of 60°, and are at right angles with the *vertical*. These solids, containing similarly four axes, are united in the class TETRAXONA, derived from τετρα, *four*, and αξων, *axis.*[†]

24. The following is a brief recapitulation of the above classification.

Cube, Regular Octahedron, Rhombic Dodecahedron,	Classis *Monometrica*, or the *Monometric System.*
Right Square Prism, Square Octahedron,	Classis *Dimetrica*, or the *Dimetric System.*
Right Rectangular Prism, Right Rhombic Prism, Rectangular Octahedron, Rhombic Octahedron,	Classis *Trimetrica*, or the *Trimetric System.*
Rhombohedron, Hexagonal Prism,	Classis *Tetraxona*, or the *Tetraxonal System.*
Right Rhomboidal Prism, Oblique Rhombic Prism,	Classis *Monoclinata*, or the *Monoclinate System.*
Oblique Rectangular Prism,	Classis *Diclinata*, or the *Diclinate System.*
Oblique Rhomboidal Prism,	Classis *Triclinata*, or the *Triclinate System.*

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[*] *Triclinohedral* of Naumann; *Tetarto-prismatic* of Mohs; *Tetarto-rhombic* of Breithaupt.

[†] *Hexagonal System* of Naumann; *Rhombohedral* of Mohs; *Monotrimetric* of Hausmann.

The primary forms in the monometric system, are solids of unvarying relative dimensions. The forms included in the other classes vary in one or more of their dimensions; the right square prism, in its height as compared with the breadth, the rectangular, rhombic, and rhomboidal prisms, in each of their dimensions.

CLEAVAGE OF PRIMARY FORMS.

25. It is a fact of common observation, that the mineral called mica, (sometimes, improperly, isinglass,) is easily split into thin transparent plates or sheets. This is often effected with but little more difficulty than attends the separation of the leaves of a book, and immediately suggests the idea, that, like a book, this mineral may be composed of a great number of closely applied leaves. This property of mica depends on its crystallization, and the process of separation is termed *cleavage*. Galena is another instance of a mineral capable of easy cleavage. It differs from mica, however, in having *three* cleavage directions at right angles with one another. This mineral, therefore, instead of splitting into thin plates, breaks into small *cubes*. Calcareous spar also admits of easy cleavage, but yields rhombohedrons. These directions, in which a crystal cleaves, are termed its ***natural joints***, and the slices obtained are called *laminæ*.

26. The facility with which cleavage may be obtained, is very unequal in different minerals. In some instances, as in the first above cited, the laminæ are separable by the fingers. In others, a slight blow of the hammer is sufficient; others require the application of a sharp-cutting instrument, and often some considerable skill in its use. When all other means fail, it may sometimes be effected by heating the mineral and plunging it, when hot, into cold water. Attempts of this kind are sometimes effectual with quartz. In many instances, cleavage cannot be effected by any means, owing to the strong cohesion betweeen the laminæ. In these cases, however, the direction of cleavage is sometimes determined by the lines on the surface. Observation of these lines is often of importance when cleavage is not difficult, in order to determine its direction, previous to applying the knife.

When cleavage is easily obtained, it is said to be eminent.

27. The general laws, with respect to cleavage, are as follow:

1. When cleavage is attainable, it is parallel to some or all of the faces of a primary form.

2. Cleavage is obtained with equal ease or difficulty, parallel to *similar* primary faces, and with very unequal ease or difficulty, parallel to *dissimilar* primary faces.

3. Cleavage, parallel to similar planes, produces planes of similar lustre and appearance, and the converse.

According to the first law, if a cube is cleavable, cleavage will either take place parallel to the faces of the same, in which case the primary form is a cube; or it may be effected on the angles, when the primary is an octahedron, or on the edges, when it will produce a dodecahedron. Cubes of fluor spar may be very readily reduced to the primary octahedron by cleavage. This is a very convenient material for the exercise of the student, who needs but his knife to succeed in effecting the cleavage.

According to the second law, cleavage can always be obtained with equal ease parallel to all the faces of a cube, octahedron, or dodecahedron; and also the rhombohedron, which is a solid contained under equal planes.

The right square prism, right rhombic prism, and oblique rhombic prism, may be cleaved with equal ease or difficulty, parallel to their lateral planes, since these are similar. Often, however, no cleavage can be effected in these prisms, except parallel to the bases, and, in many instances, not even in this direction. The right rectangular, right rhomboidal, and oblique rhomboidal prisms, have unequal cleavages in the three directions; and according to the third law, the cleavage in the three directions will produce faces of unlike lustre and general appearance. This is exemplified in gypsum; in one direction, it is cleavable with great facility into thin laminæ of perfect transparency, and highly polished surfaces; in a second direction, the crystalline laminæ first bend and then break, exhibiting a surface which is not smooth, nor possessed of much lustre; in the third direction, it is brittle, and breaks immediately on attempting to bend it, affording a surface smoother than the second, but not polished. In thick masses, the second and third cleavages are scarcely attainable. Two of these cleavages incline at an oblique angle, but are at right angles with the third; the primary form is, therefore, a right rhomboidal prism.

b. Some instances occur of apparent exceptions to the first law. They are mostly confined to the right rhombic and right rectangular prisms. The rhombic prism, in addition to a cleavage parallel to its lateral planes, may have one parallel to its lateral edges or a diagonal of the base, or what is equivalent, parallel also to the face of a secondary right rectangular prism, this prism being formed by a truncation of the edges of the rhombic prism, (§ 10.) These, however, are not real exceptions, as cleavage is still parallel to a face of a primary solid.

CHAPTER II.

SECONDARY FORMS.

LAWS FOR THE OCCURRENCE OF SECONDARY PLANES.

28. The number of secondary forms which the seven classes of primary forms are capable of affording, is exceedingly large; at least many millions, supposing them to be of invariable dimensions.

But as most of these primaries may vary their dimensions infinitely, the possible number of varieties of form is infinite. The *actually occurring* forms of a single mineral, calcareous spar, have been found to be nearly a thousand.

These planes do not occur indiscriminately on a crystal, without regard to time or place, but are governed by the following simple law:

All the similar parts of a crystal are similarly and simultaneously modified; or, by the subordinate law,

Half the similar parts of a crystal may be similarly modified independently of the other half.

The operation of the second, or subordinate law, produces *hemihedral* forms of crystals, or forms with half the number of secondary planes that perfect regularity would require. The forms resulting from the first law, are termed *holohedral* forms, from ὅλος, *all*, and ἕδρα, *face*.

29. Class 1. *Monometrica*. According to the first law, if a single edge of a cube, octahedron, or dodecahedron, be truncated, all will be simultaneously truncated, for all are similar, (§ 8, *a*; fig. 5, Pl. I.) If an edge of the same be replaced by a plane inclined unequally, on two adjacent faces, to retain the symmetry and apply the above law, a second plane must occur on this edge, similar to the first, as is represented in fig. 10. This becomes evident, when we consider that these planes occupy similar parts of the crystal, and agreeably to the above law, all similar parts must be simultaneously modified. This is termed, as stated in the note to § 8. a bevelment. It also follows, that all the edges of these solids will be similarly beveled.

Again, the truncation of *one* angle of a cube is necessarily accompanied by the truncation of *all*, (fig. 2.) If a plane, situated as a′, in fig. 14, occur on an angle of this solid, three similar planes *may*, and therefore *must*, occur on the same angle, one inclining on each face. In addition, similar planes will occur on all the angles. So, in the octahedron, we find four planes, (a′, fig. 17,) on each angle, one inclined on each face.

If an intermediary plane, (fig. 24,) is situated on the angle of a cube, it will be accompanied by five others, or there will be six in all, and forty-eight in the whole solid, (fig. 24.) The possibility of the occurrence of six similar planes, is sufficient to *require* their occurrence, since the number of similar parts about the angle is therefore six. It should be observed, that two of these six planes may be said to belong to each edge. Thus, two to the edge P : P′, two to the edge P′ : P″, and that they correspond to bevelments of the same edges. This correspondence may be seen by comparing figs. 24 and 10.

For the same reason, there will be eight intermediary planes on each angle of the octahedron, two for each of the edges. It is manifest, that if one of these intermediary planes should be dropped, the symmetry of the crystal would be destroyed.

The angles of the dodecahedron being of two kinds, (§ 8, *c*,)

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they will be independently modified. The modifications are the same as in the cube and octahedron, (figs. 6, 8, 13, 18, 27, Pl. I.)

b. The exceptions arising from the second law, are not of unfrequent occurrence. They are as follows:

1. Half the similar angles, or edges, may be modified independently of the other half.

2. All the similar angles, or edges, may be modified but by half the regular number of planes.

Figs. 28, 33, are examples of the first kind of ***hemihedrism***, in which half the angles of the cube are modified, while the remaining half are unmodified.

Fig. 42 is an instance of the second kind. All the edges are similarly replaced, but by one of the two beveling planes represented in fig. 10. The plane e′ is enlarged in fig. 43. From this last figure, it will be observed, that the suppressed planes are those which were alternate, and that two planes, e′, incline on each face, P. The symmetry of each crystal is not, therefore, destroyed.

Another instance may be observed in fig. 48, in which each angle of the cube is replaced by three out of the six intermediaries in fig. 24; that is, by one half of the number of planes which perfect regularity would require.

The *first* species of hemihedrism gives rise to solids, whose opposite planes are not parallel; a face of a tetrahedron, for example, has no opposite parallel face. The same is true of all solids resulting from this kind of replacement, and arises from the fact, that opposite parts of the crystal, producing these forms, as, for instance, the diagonally opposite angles in figs. 28 and 33, are not similarly modified. This species of hemihedral crystal, has been called the *inclined hemihedron*, for the above reason, that its opposite planes are not parallel, but inclined to one another.

On the contrary, according to the *second* species of hemihedrism, the opposite parts of a crystal are similarly replaced, and, consequently, the hemihedrons proceeding from this replacement have their opposite faces parallel. Such is the case in figs. 43 and 48. These solids have been termed *parallel hemihedrons*.

Both of these species of hemihedrons are never presented by the same mineral. The former is observed in boracite, the latter in iron pyrites, and many other species. It is also important to observe, that minerals, whose crystals are hemihedrally modified, are invariably thus modified, if the secondary planes occur, in which the hemihedrism may take place. We may illustrate this statement by a reference, first, to the species iron pyrites, whose modifications follow the second of the above laws. The cubes of this species never occur with beveled edges, but, (whenever modified,) are invariably replaced by one or two planes *unequally* inclined on the adjacent faces. Again, the angles are never replaced by *six* intermediaries, but by *three alternate*, as in fig. 48, o. In *boracite* we observe, that invariably only one half the angles are similarly replaced, and that the modified angles present all the planes required by the regular law for secondary planes. The edges of the cube are not affected by this species of hemihedrism, as it only influences the replacements of the angles.

30. Class 2. *Dimetrica.* The modifications of the basal and lateral edges of the square prism, are independent of one another, owing to their dissimilarity, (§ 9.) The lateral edges are included by equal planes, and, therefore, are universally either truncated or beveled, (figs. 61, 62.) The basal edges, being the intersections of unequal planes, are never truncated or beveled, but are simultaneously replaced, because of their similarity. A plane on these edges, therefore, inclines unequally on the adjacent faces, (fig. 53.)

For the same reason, the angles cannot be truncated. A plane on an angle inclines, however, equally on the two lateral planes M, M, in consequence of their equality, (fig. 51.)

The similar intermediary planes can be but two in number. The *two* which incline on the base, are unlike those inclining on the lateral planes, on account of the dissimilarity between the base and a lateral plane. These intermediary planes are represented in fig. 58.

It is unnecessary to state the corresponding particulars relative to the octahedron, since they are easily deduced from its relation to the prism, and, moreover, are determined without difficulty from the nature of the solid itself.

31. Class 3. *Trimetrica.* The edges of the right rectangular prism are of three kinds, and those of each kind are, according to the above law, independently modified, (figs. 70, 77, 78, 79.) Moreover, none of them can be truncated or beveled, in consequence of the inequality of their including planes.

Planes on the angles incline *unequally* on the three adjacent *unequal* planes. The angles are similar, and, therefore, will be modified in connection, (fig. 74.)

This prism can have but one intermediary on each angle. This follows from the inequality of the three edges that meet at each angle.

The lateral edges of the right rhombic prism admit of truncation and bevelment, because of the equality of the lateral planes. The obtuse are, however, modified independently of the acute, (fig. 84.) The obtuse solid angles, and the acute, are also independent in their modifications. Each may have two intermediary planes, (fig. 85.) The replacements of the basal edges are similar and simultaneous, (fig. 80.)

32. Class 4. *Monoclinata.* In the oblique rhombic prism, only the opposite of the lateral edges are similarly replaced; they may be truncated or beveled, (fig. 100.) The *front superior* basal edges are unlike the *front inferior*, or the *superior behind*,

(§ 11,) and are therefore modified independently of the latter, (fig. 101.)

The four lateral solid angles are composed of the same number of plane angles which are equal, each to each, and belong to planes which are respectively equal. Their modifications are, consequently, similar, (fig. 98.) The front angles are dissimilar, and independent in their modifications, (figs. 96, 97.)

The right rhomboidal prism, unlike the right rhombic, cannot have its lateral edges truncated or beveled. Its basal edges and angles are also dissimilarly modified. Placed on a rectangular face for its base, as in fig. 88, we may apply to it the same remark as above. The *front superior basal* edge and angles, being unlike the *front inferior* or *superior behind*, (§ 11,) they are modified independently of the latter. This is the most simple method of viewing this solid.

33. Class 5. *Triclinata*. Hereafter, the class Diclinata, will not be treated of, except in connection with the class Triclinata, both on account of the rarity of its occurrence, and the similarity of the oblique rectangular to the oblique rhomboidal prism.

In the oblique rhomboidal prism, there can be neither truncations nor bevelments. Only *diagonally opposite* parts are similarly modified, and, consequently, similar adjacent or approximate planes cannot exist. (By *approximate* planes are understood those, not opposite, which are separated by one or more planes.) The front superior basal edges are unlike in their modifications, and also unlike those of the front inferior basal. The same is the fact with the angles, (figs. 104, 105, 106.) The only similar plane to **ā**, in the solid, (fig. 104,) is its diagonally opposite ā. Such is universally the case in this solid.

34. Class 6. *Tetraxona*. The vertical solid angles of the rhombohedron are formed by the meeting of three equal planes, and equal plane angles. These angles may, therefore, be truncated, (fig. 113,) or replaced by three or six similar planes. The edges may be either *truncated* or *beveled*, for a similar reason. The terminal edges, however, are replaced independently of the lateral, (figs. 109, 115, 117, 119.)

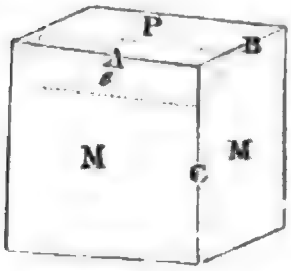
The lateral angles, six in number, are replaced at the same time, (figs. 111, 121.) Two intermediary planes may occur on each, (fig. 118.)

The similar parts in the rhombohedron and hexagonal prism, being three, or some multiple of three, (excepting the vertical solid angles,) the similar secondary plane are also three, or some multiple of three.

35. Notwithstanding the regularity in the secondary forms of crystals, resulting from the preceding laws for the occurrence of secondary planes, Crystallography would scarcely be entitled to its rank as a science, were it not for the existence of a second law. It

is this second law which gives to Crystallography a mathematical basis. It is as follows:—

2. *The ratio of the edges removed by secondary planes is a simple ratio.*



In removing the edge A, to produce the plane *e*, parts of the edges B and C are also removed. If then B and C are equal, as in the cube, the parts of B and C removed will, according to the above law, either be equal, (the edge is then truncated,) or there will be twice as much of one removed as of the other, or three times as much; that is, the ratio of the parts will be either 1 : 1, 1 : 2, 1 : 3, and also, sometimes, 1 : 4, 2 : 3, 3 : 4. Other ratios sometimes occur, but are uncommon. If B and C are unequal, the ratios will be the same, excepting, that the parts of B and C removed, will be proportional to the lengths of their edges; that is, the ratios will be 1 B : 1 C, or 1 B : 2 C, or 1 B : 3 C, or it may be, 2 B : 1 C, or 3 B : 1 C, also, 2 B : 3 C, or 3 B : 2 C. The last expression signifies a ratio of three times the length of B to twice the length of C; or, if the edge B be divided into a certain number of equal parts, and C into the same number, the plane, whose ratio is **3 B : 2 C**, cuts off three parts of B, and two of those of C. The figures are used in the same manner in the preceding expressions.

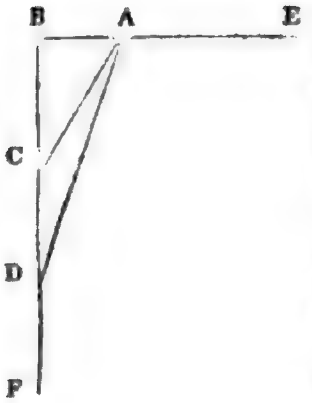
A plane on an angle, (A, B, C, again being equal,) may either cut off A, B, C, in the ratio of 1 : 1 : 1, that is, equal parts from each, or in the ratio of 1 : 1 : 2, the figures referring to the letters in the order just given; or, again, as 1 : 1 : 3, 1 : 1 : $\frac{1}{2}$, 1 : 1 : $\frac{1}{3}$, or 1 : 1 : $\frac{1}{4}$, in which the part cut from C is only one fourth that cut from either A or B. So also, there may occur the ratios 1 : 1 : $\frac{2}{3}$, 1 : 1 : $\frac{3}{4}$. Others are of occasional occurrence. If A, B, and C, are unequal, the first ratio above, that is, the ratio of equality, becomes 1 A : 1 B : 1 C; and the others, 1 A : 1 B : 2 C, 1 A : 1 B : 3 C, 1 A : 1 B : $\frac{1}{2}$ C, 1 A : 1 B : $\frac{1}{3}$ C, 1 A : 1 B : $\frac{1}{4}$ C, &c. &c. Planes *on angles* have an equal ratio of A and B, as is observed in the above examples.

Intermediary planes cut off unequal parts of the three edges, A, B, C. Some of the occuring ratios are 4 : 2 : 1, 6 : 3 : 2, that is, if these edges are divided into the same number of equal parts, the plane, whose ratio is 4 : 2 : 1, is formed by removing 4 of the parts on the edge A, 2 on the edge B, and 1 on C.

36. It has been stated, that on these principles depends the application of mathematics to this science.

A few remarks on this subject may be of interest to the student, who is acquainted with the principles of trigonometry. This subject is treated of in full, in the Appendix, A.

Let BE and BF, in the following figure, represent the two edges B and C, in the figure on the preceding page, and AC and AD, the intersections of the planes on the edge A with the face M.



If AC makes equal angles with EB and BF, the angles BAC=BCA, and therefore, (Euc. 5. I.) BA=BC. We might, therefore, conclude that the crystal is one in which the edge BE=BF, for only such can have truncating planes.

Or if we knew that BA=BC, we might infer the angle EAC, it being the supplement of BAC, which equals 45°.

Suppose again EAC to be unequal to FCA. Subtracting the angle EAC from 180°, we obtain BAC. As we are acquainted with the angles of the triangle BAC, since ACB is the complement of BAC, and ABC a right angle, we may, by the principles of right angled trigonometry, obtain the ratio of BA and BC. The proportion would be, making BA=1, R : BA=1 : : tan. BAC : BC. From the result obtained, we infer the ratio of the edges BE and BF, or the relative height and breadth of a rectangular prism.

Conversely, if the relative lengths of BA and AC, or BE and BF, are given, we may determine the angle BAC, and, consequently, its supplement EAC.

It may be stated, that it is uncertain whether the plane AC proceeds from a ratio of equality in the parts of the edges removed. This is to be presumed, or doubted, from the nature of the plane, the frequency of its occurrence, &c.; and if not, the value obtained is a multiple, or a sub-multiple of the true length of the crystal.

If the dimensions of a primary are known, we may proceed in the above manner, and calculate its interfacial angles. If we suppose the plane DA to have the ratio 2 C : B, or to cut off 2 parts of the edge C to 1 of B, the angle BAC will be determined by the proportion, B : R : : 2 C : tan. BAD, which again is the supplement of EAD. The angle FDA is determined by subtracting EAD from 270°. This will give an imperfect idea of the use of mathematics, and the manner of its application in Crystallography. For a further elucidation of this interesting subject, reference may be made to the Appendix.

DERIVATION OF SECONDARY FORMS FROM THE PRIMARIES.

37. In the remarks on the relations of the primary solids, some of the secondary forms have already been pointed out. Thus, the octahedron has been shown to be derivable from the cube, by the truncation of its solid angles, and conversely, the latter from the former, by a truncation of the angles of the octahedron. In a similar manner, the dodecahedron has been shown to proceed from the cube, from a truncation of the edges of the latter, &c. &c. (See §§ 17—23.)

We propose to continue this subject, as a perfect acquaintance with the derivative forms is of the utmost importance to the mineralogist. We again treat of the several forms, according to the classes to which they belong.

Class 1. *Monometrica.*

For the sake of perspicuity of arrangement, the ***holohedral*** and ***hemihedral*** forms will be separately considered.

38. *Holohedral Forms.*

a. Tetrahexahedron. A bevelment of the edges of a cube is represented in fig. 10, and the result of a continuation of the process in fig. 11. This form is bounded by twenty-four triangular faces, *two* planes being formed on each of the *twelve* edges of the cube. It may be considered a cube, with a low four sided pyramid on each face. The above name expresses its general resemblance to the cube or hexahedron, at the same time that it conveys an idea of the number of its faces. It is derived from τετράκις, *four times*, ἕξ, *six*, and ἕδρα, *face ;* the 4×6 faced solid.

The planes e′ in fig. 12, which are observed to replace the solid angles of the octahedron inclining at the same time on its edges, if extended to the obliteration of the primary faces, produce the same form as above, (fig. 11.)

The replacement of the *six* acute solid angles of the dodecahedron by *four* planes resting on the primaries, (fig. 13,) if continued, results in the same solid.

By varying the angle of the bevelment of the cube, tetrahexahedrons of different angles may be produced. Those of most common occurrence have the following angles :

Interfacial Angles.

	A	C[*]	
1.	= 133° 48′ 47″	157° 22′ 4 ″	
2.	143° 7′ 48″	143° 7′ 48″	occurs in garnet.
3.	154° 9′ 29″	126° 52′ 12″	“ fluor spar.

Plane Angles.

	a	*c*	
1.	= 50° 14′ 16″	79° 31′ 28″	
2.	48° 11′ 23″	83° 37′ 14″	occurs in garnet.
3.	46° 30′ 30½″	86° 58′ 59″	“ fluor spar.

b. Trisoctahedrons. The angles of the cube are represented as replaced by three planes in figs. 14 and 19 ; in one, they incline on the primary faces, in the other, on the edges of the cube. The completed forms obtained by these replacements, are seen in figs. 16 and 20. Fig. 15 is an intermediate form between 14 and 16. The resulting solids, though considerably unlike, have a general resemblance to octahedrons, with a three sided pyramid substituted for each octahedral face. Like the octahedron, they are formed on the angles of the cube by a replacement by three planes instead of one, which accounts for their general resemblance to this solid. The name, Trisoctahedron, is derived from τρις, *three times*, οκτω, *eight*, and ἑδρα, *face*, 3×8 faced solid. The faces of one of these solids are four sided, or *tetragonal*, those of the other, three sided, or *trigonal;* they are, therefore, distinguished by the names *tetragonal trisoctahedron*, and *trigonal trisoctahedron.* The more common name of the former is *trapezohedron.*

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[*] The letters designating the angles refer to the figure, Pl. I. C is, however, substituted for 2 C. The same is the case in the following forms. According to the system of notation explained in the Appendix, these solids are designated, $\infty O \frac{3}{2}$; $\infty O 2$; $\infty O 3$.

The *tetragonal* may be derived from the octahedron, by replacing its angles by four planes *inclining on its faces*, (fig. 17.)

The same may be obtained from a dodecahedron, by a truncation of its *twenty-four* edges, (fig. 18.)

The *trigonal* proceeds from the octahedron, by beveling its *twelve* edges—(compare figs. 21 and 20,) and from the dodecahedron, by a replacement of its six acute solid angles by four planes inclining on the edges.

The tetragonal trisoctahedron, or trapezohedron of most common occurrence, has the following angles:

B=131° 48′ 37″, C=146° 26′ 34″. Fig. 16.
a=82° 15′ 3″, *b*=117° 2′ 8″, *c*=78° 27′ 46″. Ex. leucite and garnet.

The trigonal trisoctahedron occurring in nature, has the following angles:

A=152° 44′ 2″, B=141° 3′ 27″, *b*=118° 4′ 10″, *c*=30° 57′ 55″.*
Fig. 20. It is a form of fluor spar and galena.

c. Hexoctahedron. Fig. 24 represents a cube, with six planes on each angle, and, consequently, forty-eight in all. The resulting solid is completed in fig. 25. Here, for each face of the octahedron, is substituted a low six sided pyramid. The name of this solid is derived from the Greek, ἑξακις, *six times*, οκτω, *eight*, and ἑδρα, *face*, 6×8 faced solid.

A replacement of the angles of the octahedron by eight planes produces a similar solid, (fig. 26.) A bevelment of the *twenty-four* edges of the dodecahedron, (fig. 27,) also necessarily produces a *forty-eight* faced solid. Others, differing in their angles, may result from a replacement of the *six* acute solid angles of the dodecahedron, by *eight* planes, or the *eight* obtuse by *six* planes.

The occurring varieties have the following interfacial and plane angles:

1. A=158° 12′ 48″, B=148° 59′ 50″, C=158° 12′ 48″, occ. in garnet.
2. 162° 14′ 50″, 154° 47′ 28″, 144° 2′ 58″, " fluor spar.
1. *a*= 86° 56′ 25″, *b*= 56° 15′ 4″, *c*= 36° 48′ 31″.
2. 85° 50′ 23″, 54° 21′ 34″, 39° 48′ 3″.†

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* The crystallographic expressions for these trisoctahedrons are, for the tetragonal, 2 O 2, for the trigonal, 2 O.

† These solids are described by means of the crystallographic signs, explained in Appendix A, as follows: 3 O $\frac{3}{2}$, 4 O 2.

39. *Hemihedral forms.*

a. Hemi-Octahedron, or *Tetrahedron.* If half the angles of the cube are replaced by a single plane, as in fig. 28, the resulting form is a tetrahedron, or hemi-octahedron, (figs. 29, 30.) The same may arise from an octahedron, by an extension of one half of its faces, to the obliteration of the other half. This process is represented as partially completed in fig. 32.

Its plane angles are 60°, and its interfacial angles 70° 31′ 44″.

b. Hemi-Trisoctahedrons. Fig. 33 represents a cube, with its alternate angles replaced by three planes. The planes in this figure occurring on all the angles, give rise to the tetragonal trisoctahedron, (fig. 16.) Occurring on but half, they produce the solid in fig. 34.

The secondary planes in fig. 19, occurring on but half the angles, and enlarged, form the solid in fig. 40, which is a hemihedral form of the trigonal trisoctahedron. Its faces are *tetragonal*, and, therefore, if a name is desirable, it may be termed the *tetragonal hemi-trisoctahedron.*

The former has *trigonal* faces, and is, therefore, the *trigonal hemi-trisoctahedron.*

A trigonal hemi-trisoctahedron of gray copper ore has the following angles:

B=109° 28′ 16″, C=146° 26′ 33″.
a= 31° 28′ 56″, b=117° 2′ 8″.*

c. Hemi-Hexoctahedrons. A solid of this kind is represented in fig. 41. It is formed by a replacement of half the angles of the cube, by six planes, similar to fig. 24.

If *all* the solid angles of the cube be replaced by *three* alternate planes, of *six* intermediaries, (§ 48,) a hemihedral solid is formed, which is represented in fig. 49. It differs from the above, in having parallel opposite faces, and is, therefore, a *parallel hemi-hexoctahedron.*

A variety of inclined hemi-hexoctahedron, having the following angles, has been observed in boracite:

A=162° 14′ 50″, B=124° 51′, C=144° 2′ 58″.†
a= 40° 19′ 7″, b= 54° 21′ 34″, c= 85° 19′ 19″.

d. Hemi-Tetrahexahedron, or *Pentagonal Dodecahedron.* A cube is represented in fig. 42, with but one of the two beveling planes on each edge, given in fig. 10. The same enlarged, is observed in fig. 43. Fig. 44 represents the completed solid. The second of the above names, is most commonly applied to this solid;

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* Its crystallographic symbol, agreeably to the notation adopted in Appendix A, O 2

e expression, descriptive of this solid, is $\frac{4O2}{2}$.

the first is more systematic, the solid being, in fact, a hemihedral form of the tetrahexahedron.

Figs. 45, 46, exhibit the planes on the octahedron, which, extended, give rise to this solid, (figs. 47, 44.)

The occurring forms of this kind, both of which have been observed in iron pyrites, have the following angles:

1. $A=112^\circ\ 37'\ 12''$, $C=117^\circ\ 29'\ 11''$.
$a=102^\circ\ 35'\ 40''$, $b=108^\circ\ 24'\ 30''$, $c=110^\circ\ 17'\ 40''$.
2. $A=126^\circ\ 52'\ 12''$, $C=113^\circ\ 34'\ 41''$.
$c=121^\circ\ 35'\ 18''$, $b=106^\circ\ 36'\ 2''$, $c=102^\circ\ 36'\ 19''$.[*]

Class *Dimetrica.*

40. *Holohedral Forms.*

The derivation of an octahedron from the right square prism, by a replacement of its solid angles by a single plane each, has already been explained. By different inclinations of this plane, different octahedrons may be obtained.

The basal edges of this solid are also eight in number, and similar, and, consequently, by their replacement at different angles, may give rise to another series of octahedrons, (figs. 53, 54.)

Two intermediate planes on each angle (fig. 58) of the prism, produce, if extended, a double eight sided pyramid, (fig. 59.) A square prism diagonal, with the primary, may be obtained by truncating its lateral edges, (fig. 61,) and an eight sided prism by beveling the same, (fig. 62.)

41. *Hemihedral Forms.*

A few hemihedral forms, appertaining to this class, are represented in figs. 63, 66, 67. The first is an irregular tetrahedron, and is formed in a similar manner with the monometric tetrahedron. The second is the commencement of the solid represented in fig. 67.

Class *Trimetrica.*

42. A replacement of the lateral edges of the right rectangular prism, has been stated to give rise to a rhombic prism. If the edges ĕ, (fig. 69.) are replaced, as in fig. 78, or the edges ē, as in fig. 77, prisms will also be formed, which, from their horizontal position, are called *horizontal prisms*, (fig. 79.) The formation of octahedrons has been explained, (§ 10.)

Class *Tetraxona.*

43. The derivation of two six sided prisms from the rhombohedron, has been fully explained in § 14; the one by a truncation of the six lateral edges, (figs. 109, 110:) the other, by a replacement

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[*] The signs of these solids are, $\frac{[\infty O \frac{3}{2}]}{2}$, $2\frac{[\infty O 2]}{2}$

of the six lateral angles, (figs. 111, 112,) by planes parallel to the vertical axis.

The remaining parts of the primary faces on the first of the above prisms, are rhombic, (fig. 110;) those on the second, are pentagonal, (fig. 112.) This is an important distinction.

In fig. 115, the lateral edges of the rhombohedron are beveled; a greater extension of these secondary planes produces the solid represented in fig. 116, which is called the *scalene dodecahedron*, its faces being scalene triangles, and its faces twelve in number.

A bevelment of the terminal edges (fig. 117) continued, gives rise to a similar solid. A replacement of the lateral angles, by two intermediary planes, (fig. 118,) may produce other solids of the same kind.

A truncation of the terminal edges of the rhombohedron, is observed in fig. 119. Since these edges are six in number, three at one end of the crystal, alternating with three at the other, the solid, formed by the extension of these planes, must be an oblique solid, contained under six equal faces, or, in a single word, a rhombohedron. This solid is represented in fig. 120. It is much more obtuse than the primary. Because, also, the lateral angles are six, and three alternate are nearer the lower extremity of the axis, and the remaining three nearer the upper extremity, the planes on these angles, if not parallel to the vertical axis, incline alternately above and below, (fig. 121;) and, therefore, by their extension, will give rise to rhombohedrons, (fig. 122.) These rhombohedrons will differ in the lengths of their vertical axes, as these planes vary their inclination. Their nearer approach to parallelism to the vertical axis, produces rhombohedrons of longer axes; and the six sided prism, formed on these angles, may be considered a rhombohedron, with an infinite axis.

An isosceles dodecahedron, (fig. 124,) so called, because its faces are isosceles triangles, may be obtained from the rhombohedron, by a replacement of the lateral angles, provided this replacement is continued to the obliteration of the primary faces, and (fig. 123) is of such a kind that the remaining primary faces (fig. 124) just equal the secondaries produced by the replacement. In fig. 124, the alternate faces R, R, are primary, and the remainder secondary. Such is the origin of the pyramidal termination of crystals of quartz. This solid may also be formed by replacing the basal edges or angles of the hexahedral prism, (e, fig. 125.)

Two intermediary planes on each angle of the hexagonal prism, produce, by their extension, a twenty-four sided figure, formed of two twelve sided pyramids placed base to base.

This solid is represented in fig. 126.

Hemihedral forms often occur in the class Tetraxona, but usually in connexion with holohedral. Under tourmaline, is represented a six sided prism of this mineral, differently terminated at its two extremities. The secondary faces *a′*, *a′*, at the upper extremity, replace the lateral angles; the secondary faces, *e*, *e*, *e*, at the lower, truncate the terminal edges; the three planes *a*, *a*, which truncate the alternate edges of the six sided prism, replace the alternate lateral angles.

The six lateral planes which compose the hexagonal prism, are formed on the six lateral *edges*, (not on the angles.) We arrive at this conclusion, by observing, that the faces P, if *a'* was removed, would be ***rhombic***, and ***not pentagonal***, as remarked in the commencement of this section.*

On the Lettering of Figures of Crystals.

44. Some difficulty is occasionally experienced by the young mineralogist in *reading* the figures of crystals, or, in other words, in determining the particular situation of each secondary plane. This obstacle can be wholly surmounted only by frequent comparisons of figures with the solids they represent. It, however, may be partially removed, and this comparison facilitated, by a simple system of *notation*, according to which, the lettering of the planes shall designate the edge or angle on which they are situated. In order that a system for this purpose should conveniently subserve its intended purpose, its principles should be few and simple. Such, it is presumed, will prove to be the character of the following.

In applying the following principles, a few of the primary forms are supposed to have a certain position:

The right rhombic prism must be placed with an obtuse lateral edge towards the observer; the right rhomboidal, (except for the lettering of its primary planes,) on its rectangular base, as in fig. 88; the oblique rhombic and rhomboidal prisms, with the dominant solid angle in front; it is immaterial whether at the inferior or superior base. Farther than this, no attention need be paid to the situation of these solids.

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* An exhibition of the relations of the secondary forms, above described, to their primaries, is beautifully accomplished by means of glass models. They may be made from common window or plate glass, by cutting the glass in the form of the faces of the solid to be made, and then uniting them by means of glue. The author has generally found it convenient to employ a small cord between two adjacent pieces of glass, as the adhesion between the glass and the cord, by means of glue, is much stronger than between two pieces of glass. The forms thus far finished, may be rendered much stronger, and, at the same time, the glue and cord concealed, by covering the edges with very narrow strips of paper, cut for the purpose; colored glazed paper is preferable, on account of its less liability to be soiled. The primaries, when thus completed, may be placed within any secondary nearly constructed, which afterwards can be closed up and its edges papered. We have thus an elegant exhibition of the relations which the secondary bears to its primary. In this way, a primary may be inclosed within any of its secondaries. The plane angles of the faces in the monometric solids, are given in the preceding paragraphs. These may be laid off on paper, and the form of the desired face obtained; by then placing the plate of glass over the figure, the faces may be cut with a diamond and a rule, without difficulty. Good glue is necessary to produce the cohesion of the glass; gum arabic suffices for attaching the slips of paper to the edges.

The primary planes of the prisms, if alike, as in the cube, are lettered P; if unlike, P is retained for the basal, and M employed for the lateral planes; and, finally, if the lateral are unlike, the larger lateral is lettered M, the smaller T, except in the right rectangular prism, whose larger lateral plane is lettered M̄, and the smaller M̆, (see figs. 69, 87.) The primary faces of the rhombohedron will be lettered R; those of the octahedron A; those of the rhombic dodecahedron E; the reason for using these letters will be seen farther on. (See figs. 3, 4, 7, 107.)

In general, the letter e may be applied to planes on the edges, a to planes on the angles, and o to intermediaries.

If the basal edges differ from the lateral, as in the prisms, the Roman e may be retained for the basal, and the Italic *e* for the lateral.

If any of the edges are oblique, we may distinguish the *obtuse* by the mark -, the *acute* by the mark ⌣, and thus may have ē, ĕ, for planes on the obtuse and acute basal edges in the oblique prisms, (fig. 91,) *ē*, *ĕ*, for planes on the obtuse and acute lateral edges. In the right rhomboidal prism, the front superior basal edge is obtuse ē, the inferior acute ĕ, while the lateral are rectangular, and are, therefore, lettered e simply. (See fig. 88.)

In the oblique rhomboidal prism, there are two unlike obtuse basal edges, and two unlike acute. We may letter planes on the edge to the right hand, ē·, or ĕ·, on that to the left, ·ē or ·ĕ.

If the front angles differ from the lateral, as in the rhombic and rhomboidal prisms, we may retain the Roman a for the front, and employ the Italic *a* for the lateral. (fig. 72.)

If the front angles at the two bases differ, as in the oblique prism, the planes on the obtuse may be distinguished by ā, those on the acute by ă, (figs. 96, 97.)

In the rhombohedron, the vertical solid angle may be lettered a, the lateral *a;* the terminal edges e, the lateral *e*.

All the monometric solids will be hereafter lettered, as if derived from the cube. In the other classes, the lettering will depend on the primary.

The changes of the letter o for intermediaries, and the use of the marks — and ⌣, will follow the same changes in the letter a. That is, intermediary planes about the angle ā will be lettered ō, those about the angle *a*, *o*.

The different planes on the same edge or angle, may be distinguished by indices, as follows: a′, a″, a‴, a^4, a^5, &c.

The main principles in this system of notation are:

1. Lettering planes on edges, e, on angles, a, and intermediaries, o.

2. Distinguishing planes on the basal edges from those on the lateral, by lettering the former with a Roman e, and the latter with an Italic *e*.

3. Distinguishing planes on *obtuse* edges from those on *acute*,

by placing the mark — over the letter for the former, and ⌣ for the latter, as ē, ĕ, *ē*, *ĕ*.

4. Distinguishing planes on the frontal angles from those on the lateral, by lettering the former with a Roman a, the latter with an Italic *a*.

5. Distinguishing planes on obtuse frontal solid angles from those on acute, by the mark — over the letter for the former, and ⌣ for the latter.

CHAPTER III.

DETERMINATION OF PRIMARY FORMS.

45. With a perfect understanding of the preceding sections, we are prepared to enter on the subject of the determination of the primary forms of minerals, by inspection of their crystals. This is one of the main objects of the study of crystallography. The first question which arises, on commencing the examination of a crystal, is, what is its primary? To afford the means of overcoming the various difficulties in the answering of this question, this subject will be fully discussed.

46. These difficulties are of several kinds, but arise principally from the accidental variations of form to which crystals are subject —variations affecting the size of their faces, and sometimes the angles. For example: a mineral, whose primary is a cube, often occurs under the form of a right square or right rectangular prism; a right square prism may appear to have the form of a cube, or a right rectangular prism; a rhombohedron may appear to be an oblique rhombic or an oblique rhomboidal prism. So that, in fact, but little dependence can be placed on a mere observation of the apparent form.

Another difficulty appears to follow from the great variety of secondary planes, which often completely mask the primary. This, however, will be found *not* to be a difficulty; on the contrary, the secondary planes will prove to be the surest index of the nucleus. But difficulties may proceed from the enlargement of some secondary planes, and the consequent diminution of others of the same kind. Very singular distortions of this kind occur. Under quartz, p. 339, is a representation of a distorted crystal of that mineral.

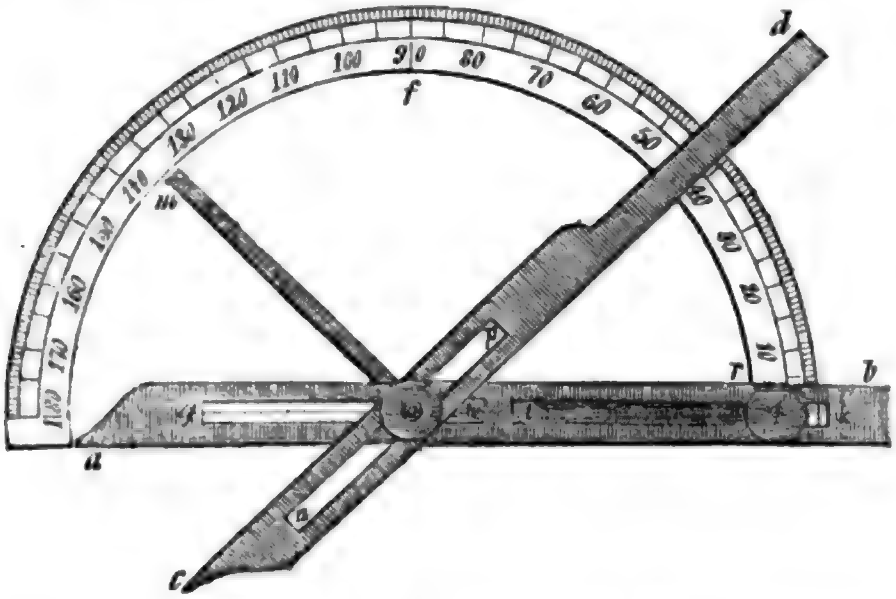
Difficulties also arise from the imperfection of crystals; these, however, will generally prove no obstacle to one well acquainted with the preceding principles, and the following remarks, which are deductions from these principles.

46. The methods which may be employed in the determination of the primary of a mineral, are as follow:

1. Measurement of angles.
2. Inspection of the similarity or dissimilarity of lustre, hardness, &c., of different faces.
3. Cleavage.
4. Examination of the situation of secondary planes.

1. MEASUREMENT OF ANGLES.

47. The measurement of the angles of crystals is effected by means of instruments called *Goniometers*.

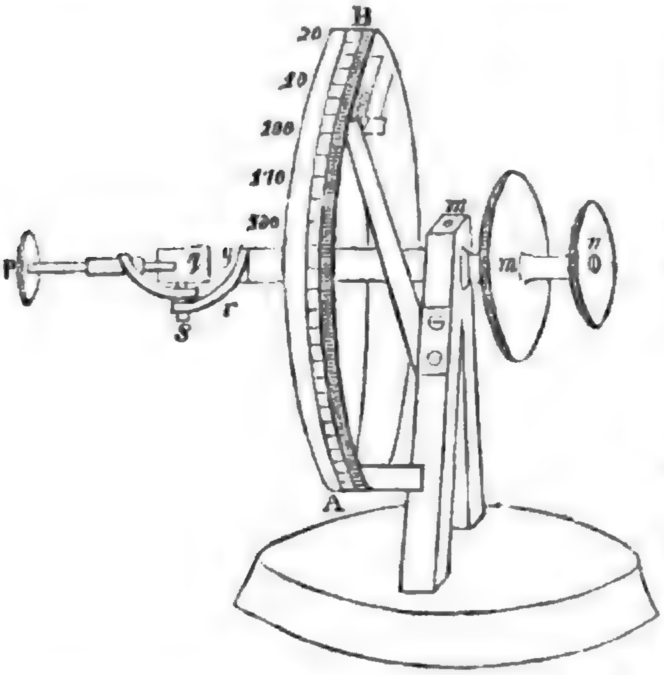


The simplest of these instruments, called the Common Goniometer, is above represented. It consists, 1. of a semicircular arc graduated to degrees, and, consequently, measuring 180°; 2. two arms, one of which, *ab*, is stationary, or admits only of a sliding motion backward and forward, by means of the slits *gh*, *ik*. The other arm turns on *o*, the centre of the arc, as an axis; there is also a slit, *np*, in this arm. By means of these slits, the parts of the arms below *o*, that is, *ao*, *co*, may be shortened, which is found necessary for the measurement of small crystals. The faces, whose inclination is to be measured, are applied between the arms *ao*, *co*, which are opened till they just admit the crystal, and are seen to be closely applied on the surfaces of the same. This may be determined by close examination, holding it at the same time up to the light, and observing that no light passes between the arm and the plane of the crystal. The number of degrees on the arc, between *k* and the *left edge* of *d*, (this edge being in the line of the centre *o* of the arc,) is the required angle.

For the purpose of measuring crystals partially imbedded, the arc is usually jointed at *f*, so that the part, *af*, may be folded back on the other quadrant. When the angle has been measured, the arms are to be secured in their place by the screw at *o*, and the arc restored to its former position and there fastened by the bar, *mo*. The angle may now be read off.

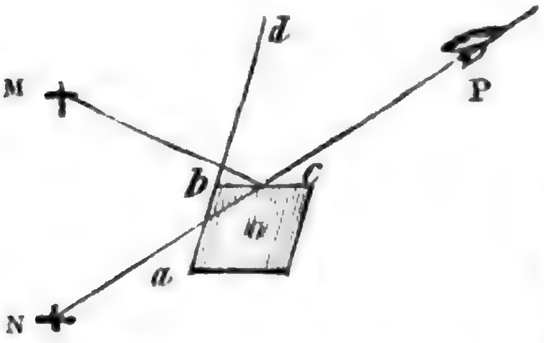
The arms sometimes admit of being separated from the arc, in order to obtain more conveniently the required angle. They may then be adjusted to the arc by a simple contrivance, which will be understood by the observer without explanation, and the angle read off as above.

The results obtained with the common goniometer are seldom within a quarter of a degree of truth. It is, however, sufficiently accurate for the ordinary observations of the mineralogist. When the crystal is destitute of lustre, it is indispensably necessary. But for highly polished crystals, we have an incomparably superior instrument in the *Reflective Goniometer*, of Wollaston.



48. The reflective goniometer is represented in the adjoining figure.

The principle on which this instrument is constructed may be understood, by reference to the following figure, which represents a crystal, whose angle, *abc*, is required.



The eye at P, looking into the face of the crystal, *bc*, observes a reflected image of M, in the direction of PN. The crystal may now be so changed in its position, that the same image is seen reflected by the next face, and in the same direction, PN. To effect this, the crystal must be turned around, until *abc* has the present direction of *bc*. The angle *dbc*, measures, therefore, the number of degrees through which the crystal must be turned. But *dbc*, subtracted from 180°, equals the required angle of the crystal *abc*. The crystal is, therefore, passed in its revolution through a number of degrees, which, subtracted from 180, gives the required angle. This angle might be measured by attaching the crystal to a graduating circle, which shall turn with the crystal. This is effected by the ingenious, and beatifully simple contrivance of Wollaston, to whom science is much indebted for rendering the above principle of optics, subservient to the purposes of the mineralogist.

AB is the circle graduated to half degrees. By means of the vernier, *v*, minutes are measured. The wheel, *m*, is attached to the main axis, and moves the graduated circle together with the adjusted crystal. The wheel, *n*, is connected with an axis which passes through the main axis, (which is hollow for the purpose,) and moves merely the parts to which the crystal is attached, in order to assist in its adjustment. The contrivances for the adjustment of the crystal, are at *p*, *q*, *r*. To use the instrument, it must be placed on a small stand or a table, and so elevated, as to allow the observer to rest his elbows on the table. The whole, thus firmly arranged, is to be placed in front of a window, distant from the same from six to twelve feet, and with the axis of the instrument parallel to it. Preparatory to operation, a dark line must be drawn below the window near the floor, parallel to the bars of the window.

The crystal is to be attached to the moveable plate, *q*, by a piece of wax, and so arranged, that the edge of intersection of the two planes forming the required angle, shall be in a line with the axis of the instrument. This is effected by varying its situation on the plate, *q*, or the situation of the plate itself, or by means of the adjacent joints and wheel, *r*, *s*, *p*.

When apparently adjusted, the eye must be brought close to the crystal, nearly in contact with it, and on looking into a face, part of the window will be seen reflected, one bar of which must be selected for the experiment. If the crystal is correctly adjusted, the selected bar will appear horizontal, and on turning the wheel *n*, till this bar as reflected, is observed to approach the dark line below seen in a direct view, it will be found to be parallel to this dark line, and ultimately to coincide with it. If there is not a perfect coincidence, the adjustment must be altered until this coincidence is obtained. Continue then the revolution of the wheel, *n*, till the same bar is seen by reflection in the next face, and if here there is also a coincidence of the reflected bar with the dark line seen direct, the adjustment is complete; if not, alterations must be made, and the first face again tried. A few successive trials of the two faces, will enable one to obtain a perfect adjustment.

When adjusted, 180° on the arc must be brought opposite 0, on the vernier. The coincidence of the bar and dark line is then to be obtained, by turning the wheel *n*. As soon as obtained, the wheel, *m*, should be turned until the same coincidence is observed, by means of the next face of the crystal. If a line on the graduated circle now corresponds with 0 on the vernier, the angle is immediately determined by the number of degrees marked by this line. If no line corresponds with 0, we must observe which line on the vernier coincides with one on the circle. If it is the 18th on the vernier, and the line on the circle next below 0 on the vernier marks 125°, the required angle is 121° 18′; if this line marks 125° 30′, the required angle is 125° 48′.

If the observer is near sighted, and incapable of seeing the dark line at the above distance, a slate, or board of a similar form and size, may be secured on the table at that distance which best accommodates the eye, and its upper edge used for the bar of the window, and the lower, or a line drawn on the board parallel to the upper, for the dark line.

When great accuracy is required, and the instrument is near the window, a cord extended across the window may be substituted for the bar.

One of the most important advantages of this instrument, is its capability of measuring the angles of crystals too minute for the application of the common goniometer. Indeed, in general, the smaller the crystal the more accurate is the result obtained. Its faces are less frequently interrupted by blemishes, and are more perfectly uniform planes.

49. In goniometrical measurements, a knowledge of the following simple principle in mathematics is of great importance. "*The sum of the three angles of a triangle equals* 180°," or, in more general terms, "*The sum of the angles of a polygon equals twice as many right angles as there are sides less two.*" If there are five sides, the figure contains $2\times(5-2)=6$ right angles or 540°.

If, (see figure to § 36,) the angle CAE has been measured, the angle ACF may be determined according to the above principle, by subtracting CAE from 270°. For the two angles, BAC, BCA, since ABC is a right angle, equal 90°; also, BAC, CAE, BCA, ACF, added together, equal 360°. Subtracting the two which equal 90°, it leaves the sum of EAC, FCA, equal to 270°, and, consequently, as above stated, if EAC is determined we may ascertain the value of the other by subtracting from 270°.

Having then measured EAC, in every instance when practicable the angle FCA should also be measured. If the sum of the two angles thus obtained equals 270°, we may be quite confident of the correctness of the measurement; but if not, the measurement should be repeated.

If the angle EBF is oblique, the sum of the two angles, FCA and EAC, can be obtained, by subtracting the angle EBF from 180°, which will give the value of the two other angles in the triangle, viz. BCA and BAC, and then subtracting the result thus obtained from 360°. This gives the sum of the two angles FCA, EAC. For example, if EBF=110°, 180°−110°=70°, and then 360°−70°=290°. If, therefore, we find by the goniometer that the two angles equal 290°, the coincidence between experiment and calculation is quite sure proof of accuracy. If there is not this coincidence, the measurements should be repeated. In this manner may errors be avoided in the measurements of crystals, which would otherwise obtain.

In the determination of the primary of a mineral, the goniometer alone is sufficient only when the primary form is actually before the observer, and it is desired to determine whether the interfacial angles of the prism are right or oblique; also, if oblique, their obliquity. It performs, however, an important service in affording assistance in the employment of the other methods.

2. SIMILARITY, OR DISSIMILARITY OF THE DIFFERENT FACES.

50. This method is founded on the principle, that *like* crystalline faces *are invariably* similar in lustre and general appearance, and that *unlike* faces may be dissimilar in these characters.

The faces may differ in their lustre merely, or may be marked by lines or parallel ridges, and consequent depressions. The latter are termed striæ, and such a surface is said to be striated.

If a right rectangular prism, (as of iron pyrites,) presents on examination, similar lines or striæ on the six faces, and also a similarity of lustre, we are led to infer, that the primary is a cube. If the similarity existed between the surfaces only, we would conclude it to be a right square prism.

The difference of lustre of different faces is frequently but slight, and in general appearance they are often very closely similar. We are therefore compelled, in most instances, to employ other methods of arriving at the primary form. The dissimilarity in hardness may be of some importance; but, in general, it is not sufficiently distinct to be determined.

3. CLEAVAGE.

51. This method depends on the observation of the form obtained by cleavage, in connexion with the constant principle, that cleavage takes place with equal ease parallel to similar faces, and to those only; and that similar cleavages produce faces of similar lustre, (§ 26, 27.) Two cleavages are said to be similar, when obtained with equal difficulty, or are equally unattainable, as well as when effected with equal ease. The following table exhibits the cleavages of the several prismatic primaries:

Three similar cleavages: Cube and Rhombohedron.
Two similar cleavages: Right Square Prism, Right Rhombic Prism, and Oblique Rhomboidal Prism.
Three dissimilar cleavages: Right Rectangular Prism, Right Rhomboidal Prism, and Oblique Rhomboidal Prism.

If we observe a crystal with two similar rectangular cleavages, and a third unlike the other two, the primary, according to the above, is a right square prism. If the two similar cleavages are obliquely inclined to one another, but at the same time, at right angles with the third, the form is a right rhombic prism. We may generally distinguish, when the faces have oblique inclinations, by inspection merely; in doubtful cases, the goniometer may be employed. When we observe three equal oblique cleavages, the form under consideration is rhombohedral; if these cleavages are rectangular, the form is the cube.

Minute observation is seldom required in the determination of the similarity of two cleavages; for the difference, if any exists, is usually strongly marked. Anhydrite is a single exception to this remark. Its three rectangular cleavages are quite similar, though, with close examination, peculiarities are readily observed in each of them.

The employment of this method of determining the primary form, is often attended with considerable uncertainty, arising from the existence of other cleavages in crystals, besides those parallel to the faces of the primary. Some reference to this subject has already been made in § 27, *b*, where it is stated that a rhombic prism may have the cleavage of a rectangular prism, and vice versâ. In these cases, we must decide from analogy, either assuming those planes to be primary, parallel to which cleavage is obtained with the greatest facility, or, in some instances, those which are of the most frequent occurrence. The instances are very numerous in which this character entirely fails of affording any assistance, on account of the difficulty with which cleavage is obtained. Occasionally, we may be guided by the cleavage joints, which are sometimes apparent when cleavage is unattainable.

4. SITUATION OF SECONDARY PLANES.

52. This is the most important of the four methods for the determination of the primary of a crystal. It will merely lead us, however, to the class to which the crystal belongs, as all the forms of the same class may have the same secondaries. For example; the rhombic prism may occur under the form of a secondary rectangular, and all the modifications of a rectangular prism, may be referred to a right rhombic, (§ 10.) But for the determination of a mineral, a knowledge of the class is usually sufficient. This being known, by an examination of the angles, if convenient, and other characters, we soon arrive at the name sought. Generally the planes on two or three edges, or on an angle or two, are sufficient for this purpose, and, consequently, an imperfect crystal is often adequate to give full information. The goniometer may frequently afford assistance, but usually the results may be obtained by mere inspection.

53. The principles of this method have already been laid down in § 28; they depend on the law, that *similar parts of a crystal are similarly modified*. According to this law, the following table is constructed, in which the peculiarities of the situation of secondary planes in each class, are so laid down, that the whole may be comprehended at a single glance.

The position of the right rhomboidal prism, assumed in the table, is that represented in fig. 88. The peculiarities of its secondary planes, with reference to its situation on its rhomboidal base, are described in a note.

SITUATION OF SECONDARY PLANES.

<table>
<tr><td colspan="4">1. All the edges similarly modified.
2. Angles truncated or replaced by three or six similar planes.</td><td>Cube.
Regular Octahedron.
Rhombic Dodecahedron.</td><td>Class
MONOMETRICA.</td></tr>
<tr><td rowspan="6">1. All the edges not similarly modified.
2. Two* or none of the angles truncated or replaced by three or six similar planes.</td><td colspan="3">The number of similar planes at each extremity of the crystal, either 3 or some multiple of 3.</td><td>Rhombohedron.
Hexagonal Prism.</td><td>Class
TETRAXONA.</td></tr>
<tr><td rowspan="5">The number of similar planes at each extremity of the crystal, neither 3, nor a multiple of 3.</td><td rowspan="3">The superior basal modifications in front not similar to the corresponding inferior in front or superior behind.</td><td>Two adjacent or two approximate similar planes impossible.</td><td>Oblique Rhomboidal Prism.</td><td>Class
TRICLINATA.</td></tr>
<tr><td>Two adjacent, or two approximate similar planes possible.</td><td>Oblique Rhombic Prism.
Right Rhomboidal Prism.</td><td>Class
MONOCLINATA.</td></tr>
<tr><td colspan="3">N. B. The Right Rhomboidal Prism on its Rhomboidal base may be distinguished from the other right prisms by the dissimilar modifications of its lateral and basal edges and angles.</td></tr>
<tr><td rowspan="2">The superior basal modifications in front similar to the corresponding inferior in front, or superior behind.</td><td>1. the similar secondary planes at each base either 4 or 8 in number.
2. all the lateral edges (if modified) simil. truncated or beveled.†</td><td>Right Square Prism.
Square Octahedron.</td><td>Class
DIMETRICA.</td></tr>
<tr><td>1. the similar secondary planes at each base, either 2 or 4 in number.
2. all the lateral edges, (if modified) not similarly truncated or beveled.†</td><td>Right Rectangular Prism.
Right Rhombic Prism.
Rectangular Octahedron.
Rhombic Octahedron.</td><td>Class
TRIMETRICA.</td></tr>
</table>

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* The rhombohedron is the only solid included in this division, any of whose angles admit of a truncation or replacement by three or six planes.

† The terminal edges of the octahedrons are here termed lateral, in order that these statements may be generally applicable both to prisms and octahedrons.

In the determination of the similarity or dissimilarity of planes, the following laws are of the utmost importance, and their application will often prove a similarity, where, from the great dissimilarity in the size of the planes, it was not supposed to exist.

1. Planes equally inclined to the same plane, are similar.
2. Planes equally inclined to similar planes, are similar.

54. The following are a few examples of the mode of applying this table. We may select, first, fig. 1, of the species *iron pyrites.* Its primary form is required.

We inquire, *first*, are all the edges similarly modified? We observe that they are; and, therefore, the crystal belongs to the monometric system. The particular primary may be determined by either of the three preceding methods.

The perfect symmetry in the forms of this class is so remarkable, that a cursory glance will distinguish them immediately from any of the other classes, without a particular examination of the above fact.

Respecting a figure of calcareous spar, (see the description of this species, in the descriptive part of this treatise,) we ask the same question, but find that all the edges are not similarly modified, and the angles are not truncated or beveled. The general appearance of the crystal alone would distinguish it from the monometric forms. We proceed and inquire, *second*, Is the number of similar planes, at each extremity of the crystal, in any instance, either three or a multiple of three? We observe, in the figure, one R at the upper end, and two at the lower. These latter must have their opposites above, and, therefore, there are three R s at the upper extremity. This is sufficient to decide the question in the affirmative. But, looking farther, we also find that there are three planes e, two are visible at the upper extremity, and the third is seen below. In these examinations, it may be taken as an invariable rule, that the number of faces of any one kind, represented at *both* extremities of a *figure* of a crystal, indicates the number actually existing at *each* extremity, and for the reason that each face has one similar to it, diagonally opposite. Hemihedrism produces some exceptions, but they will cause no difficulty in the application of the above principle.

To continue, we observe, on this principle, six planes e', at each extremity, six planes e', three planes a'' and a'; so that, in every instance, the number of planes of the same kind is either three, or a multiple of three. The same will prove to be the fact with the figures of apatite, quartz, &c.

We therefore conclude, that this crystal has either a rhombohedron or a hexagonal prism, as its primary; that is, it belongs to the class *Tetraxona*. We may infer, that the rhombohedron is the primary, from the occurrence of only three planes of some kinds; the hexagonal prism is always modified with at least six planes of each kind, at each extremity. See figures of crystals of beryl, &c.

For farther elucidation, we may consider figures of the species pyroxene and anorthite. In answer to the first and second queries, with respect to these figures, we receive a negative reply. There are not three planes of any one kind at either extremity of these crystals. We, hence, make the *third* inquiry, are the front superior basal edges and angles modified in the same manner as those below, or the posterior above? This is not true with either figure. In the figure of pyroxene, the plane ă has no corresponding one above; so, also, there are two planes on an inferior basal edge of anorthite, and but one on the corresponding superior. Other planes concur in deciding the question in the negative: but a single instance is sufficient.

The figures, therefore, belong to oblique prisms, and may be of the class *Monoclinata* or *Triclinata*.

We then make the subordinate inquiry, Are there two adjacent or approximate similar planes in these crystals. In the figure of pyroxene we observe two similar Ms. If we doubted their similarity, we might decide it by finding with the goniometer, that ĕ inclined equally on these planes. Our conclusion is then immediate, that the crystal belongs to the Monoclinate system. We might also observe the pairs of faces, *ō, ō, a, a,* &c., and thus could dispense with any measurement.

On examining the figure of anorthite with the same inquiry, we find no adjacent or approximate similar planes; no plane on the edge P : T, corresponding with that on the edge P : M. The planes ·*a*, *a*·, which appear to be similar, are unlike in their inclinations, and are therefore dissimilar. Indeed, look the whole figure through, we find no two similar planes. We hence have no room for a doubt, that this crystal is *triclinate*.

Again. With a view of examining fig. 2, of the species *heavy spar*, we make the same, *first*, *second*, and *third* inquiries, and find that the reply to each is in the negative. We observe, that the similar planes are not in any instance a multiple of three, that there are similar planes, a a, *a a*, e e, at each extremity in front. We, therefore, continue the investigation, by making the fourth inquiry, Are there in each instance, four or eight similar secondary planes at the extremities of the crystals, or are there but two, and not more than four, of some planes? We observe but two planes, *a*. We need look no farther; the crystal belongs to the trimetric system. If we look farther, we find only two planes, a, and four planes, ŏ. If these four planes were the only secondaries at each extremity, it would be necessary to look to the planes on the edges, and ask, *fifthly*, Are all the lateral edges similarly truncated or beveled? But evidently, the plane ĕ differs from plane ē. This decides again the figure to represent a trimetric solid. With reference to fig. 3, of idocrase, we observe the lateral edges similarly truncated and beveled; we also find eight planes, o', o'', o''', o^4, &c. The conclusion is therefore drawn, without hesitation, that the figure belongs to a dimetric crystal, and has a right square prism, or a square octahedron for its primary.

The reader is advised to select from the figures in the descriptive part of this treatise, and attempt to apply the above principles, in order to become fully acquainted with them. In their application, if the crystal has a prismatic form, we may consider any of the faces of the prism as lateral planes, (with this restriction, that if one of two similar planes be selected, the other must also be,) for the above interrogations will apply equally well, whatever selection be made, and the conclusions will be equally correct. Thus, in the figure of heavy spar, we may assume $\bar{e}$ and $\breve{e}$ for primary planes, and still the conclusion will be obtained, that the crystal is trimetric.

DIFFICULTIES IN THE DETERMINATION OF A PRIMARY ARISING FROM PSEUDOMORPHISM.

55. *A pseudomorphous crystal, is one which possesses a form that is foreign to it, and which it has received from some other cause, distinct from its own powers of crystallization.*

Pseudomorphous crystals may arise in different ways; either by the infiltration of foreign matter into the cavities of decomposed crystals; by the external accretion of foreign matter on the surfaces of crystals; or by a decomposition of a mineral, and its gradual replacement by another possessing some points of resemblance with the original mineral in its chemical constitution.

The two first methods are readily comprehended; in the first, the cavity acts the part of a mould, and gives all its peculiarity of form to the mineral that may infiltrate into it; in the second, a series of coatings are supposed to be formed around a crystal and thus to produce a solid, presenting the form of the included crystal, though entirely different in chemical composition. The last method stated above, is by far the most frequent source of pseudomorphs, though the process by which they have been formed is often very obscure. A number of changes of this kind have been described by Haidinger, in vols. ix and x, of Brewster's Edinburgh Journal. *Specular iron*, the form of whose crystals is rhombohedral, has been observed in regular octahedrons, which is the primary of *magnetic iron ore*. The crystal, originally, belonged to the latter species; but a change of composition has taken place, without an accompanying change in the external form. Magnetic iron consists of one atom of protoxyd, and two of peroxyd of iron; specular iron, of pure peroxyd of iron: the only change required, therefore, is an additional oxydation of the protoxyd of iron, by which the whole becomes peroxyd or specular iron. In a similar manner, crystals of carbonate of lead, or *white lead*, are occasionally changed into *minium*, or oxyd of lead, without the least alteration in external form, the striæ of the surface remaining perfect. Similarly, minium may present the form of galena; Witherite, or carbonate of barytes, the form of sulphate of barytes or heavy spar; tungstate of iron or wolfram, the form of tungstate of lime, &c. In the last instance, there is merely a substitution of iron for lime, which would readily take place, provided iron were present, if any decomposing agent should remove the lime. Forms of this kind have been observed at Monroe, Conn. Other instances of more difficult explanation, are, the pseudomorphs of Prehnite, imitative of analcime; of steatite, imitative of quartz or calcareous spar; of quartz, imitative of fluor or calcareous spar. Haidinger supposes, with respect to the last, that "water, charged with carbonic acid, and by that means holding silica in solution, may have dissolved the original species, and deposited the siliceous matter in its stead." It has long been disputed, whether the crystals of serpentine were pseudomorphous. This subject has lately been investigated by A. Quenstedt, (*Annalen der Physik*, etc. No. 11. 1835,) who finds them identical in form with crystals of chrysolite, and shows, that the change requires merely an addition of water, and a removal of a part of the magnesia, and may, therefore, be effected by the very common agents, aqueous vapor and carbonic acid.*

It may be doubted whether the first species of pseudomorphism pointed out above, ever takes place in nature. More probably, those cases which have been supposed instances of it, would more correctly be referred to the last method.

Pseudomorphous crystals are distinguished, generally, by their rounded angles, dull surfaces, destitution of cleavage joints, and often granular composition. Their surfaces are frequently drusy, or covered with minute crystals. Occasionally, however, the resemblance to real crystals is so very perfect, that they are distinguished with difficulty. A total want of cleavage is their most constant peculiarity.

CHAPTER IV.

COMPOUND CRYSTALLINE STRUCTURE.

56. The compound crystalline structure of minerals may arise either from a modification of the regular laws of crystallization, resulting from the nature of these laws, or a modification produced by the influence of other causes, in connection with these laws.

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* Serpentine is represented by the following formula:—

$$3\dot{M}g\,\underline{\dot{H}}^{2}+2\dot{M}g^{3}\,\dddot{Si}^{2} \text{ and chrysolite by } \dot{M}g^{3}Si.$$

If to four atoms of chrysolite $=\dot{M}g^{12}\dddot{S}^{4}=2\dot{M}g^{3}\dddot{S}^{2}+\dot{M}g^{6}$, we add 6 atoms of water $=6\underline{\dot{H}}$, we obtain for serpentine, $2\dot{M}g^{3}\dddot{S}^{2}+3\dot{M}g\underline{\dot{H}}^{2}$, together with three atoms of magnesia, which are separated from the compound.

In the first case, the mineral still presents, externally, crystalline faces, and the individuals consist of two or more crystals intimately united in their internal structure. They are called ***Compound*** or *Twin Crystals.*

The second kind of compound structure is exemplified in specimens which are said to be imperfectly crystalline, and which are aggregations of numerous imperfect crystals, either laterally apposed, as in the fibrous structure, or confusedly mingled, as in minerals of a granular structure.

1. COMPOUND CRYSTALS.

57. Compound crystals are the analogues of monsters in the animal kingdom. They may be composed of two united crystals, or of several.

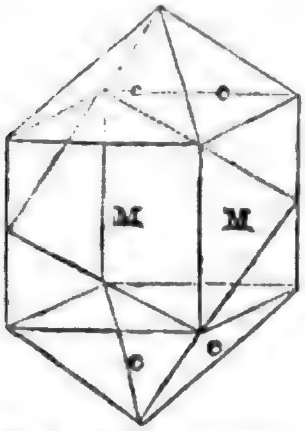
Compound Crystals, composed of two individuals, or Twin Crystals.

Representations of some of these compound forms are given in figs. 13, 14, 15, 16, Pl. III. Their structure may be imitated by cutting a model of a crystal in two halves, inverting one of the halves, or revolving it 180°, and then applying it thus inverted to the other half, bringing the same surfaces in contact that were separated. Fig. 128 is an octahedron, which is represented as cut in two in the plane, *a, b, c, d, e, f.* If we now revolve one half 60° or 180°, and reapply it to the other, it produces the forms in fig. 129.

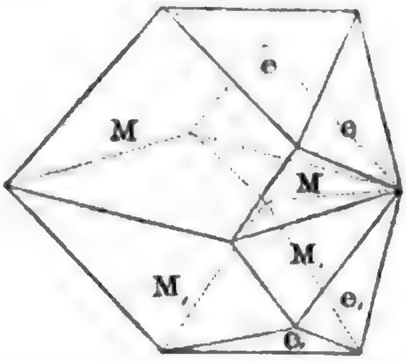
If a rhombic prism is divided in a vertical plane, parallel to a lateral face, (fig. 130,) as it were on an axis passing from M to the opposite face, the form, (fig. 131,) is obtained. This is easily verified by actual experiment.

If the same rhombic prism were divided in the diagonal section, and a similar revolution of one half were made, no twin crystal would result. But were the prism an *oblique* rhombic, in which case, the base would be inclined to the lateral planes, a solid similar to that in fig. 14, Pl. III., would be obtained.

1



2



The first of the above figures is a right square prism, terminated by four sided pyramids. This solid we may bisect in the plane, which is a diagonal section passing from one solid angle to the opposite. One half inverted and applied to the other produces fig. 2.

We have thus described all the kinds of twin crystals composed of two individuals, that occur in nature.

1. In the *first*, composition was effected parallel to a primary face.
2. In the *second*, parallel to a plane on an edge.
3. In the *third*, parallel to a plane on an angle.

The plane on an edge referred to, is the truncating plane of the same, or what corresponds to it in the inequilateral primaries; that is, it has the simple ratio 1 A : 1 B. (§ 35.) Also the plane on an angle is the truncating plane of the same, or that which has the simple ratio 1 A : 1 B : 1 C.

The twin crystals produced by the above methods, will hereafter be described as twin crystals of the *first*, *second*, and *third* kinds.

Composition parallel to some other plane on an edge, or angle, occasionally occurs in crystals which are hemihedrally modified, or which invariably present a certain secondary form, proving some peculiarity in the nature of the attractions by which the crystal is governed.

These crystals may be modified by secondary planes in the same manner as simple crystals, and thus are often produced some of the most complex solids that engage the attention of the crystallographer.

Fig. 16, Pl. III., is a scalene dodecahedron of calc spar, in which composition has apparently taken place, parallel to a horizontal section through its centre. By considering the situation of the primary rhombohedron in this solid, it is perceived that the composition is parallel to the plane truncating the terminal solid angle, and is, consequently, of the *third* kind. This figure presents none of the faces of the rhombohedron, which indicates the perfect union that exists between the two individuals, or rather, that their union was cotemporaneous with the commencement of their formation, and proceeds from the double nature of the first stone that was laid in the construction of the crystal. These forms are, in this respect, distinct from a kind of compound crystal, arising from the union of two crystals some time subsequent to the commencement of their formation. The forms above described, are *connatal* compound crystal, those just referred to, *postnatal*; the commencemencement of the former being cotemporaneous with that of the crystals composing them, while in the latter, it is subsequent to the same.

Compound Crystals, composed of more than two Individuals.

58. The same kind of composition often takes place parallel to more than one primary face, edge, or angle, and thus are produced compound crystals, composed of several individuals. Fig. 3, Pl. IV., is a hexagonally prismatic crystal of white lead, in which composi-

tion has taken place parallel to two primary faces. This crystal resembles a secondary to a rhombohedron or hexagonal prism, but is distinguished by the inequality of its lateral angles. Fig. 5, Pl. IV., is a stellated form of carbonate of lead, in which the composition is parallel to all the lateral faces.

This subject will be continued more at length in a future section when treating of the internal structure of crystals.

Compound crystals may usually be distinguished by their reentering angles, or by the striæ on their surface. These striæ meet at an angle in the line where composition has taken place. (See a figure of a compound crystal of chrysoberyl.)

It is very possible that twins of the first kind may occur in the rectangular prisms, which are not distinguishable on account of the rectangularity of the crystals. An attempt to form a twin crystal of the first kind out of a rectangular prism, that would exhibit its compound structure, would be ineffectual. It requires obliquity in some of the interfacial angles. Some undoubted instances of the occurrence of a compound nature, in crystals of this kind, have been detected by Sir David Brewster, by the assistance of polarized light.

Postnatal Compound Crystals.

59. We have already defined postnatal twins, to be those in which the composition has taken place, after each crystal had attained some considerable size. Figure 9, of quartz, represents one of these double crystals. The simple crystals in these instances are uniformly united by similar parts, and, consequently, have their similar faces parallel.

Groups of crystals, consisting of aggregations of crystals of various sizes, are frequently instances of postnatal composition. Often, however, the aggregation is very irregular.

The doubly geniculated crystals are instances of a second kind of postnatal compound crystal. One of the forms is represented in fig. 12, Pl. IV. These geniculations were evidently formed after the crystal had attained some size, and not at the commencement of its formation. (For a more particular account of the structure of these forms, see the remarks on Crystallography, (§ 74—79.)

2. AGGREGATIONS OF IMPERFECT CRYSTALS.

60. The greater part, and probably all, of the specimens of minerals that occur on our globe, may be described as aggregations of imperfect crystals. Even those whose structure appears the most purely impalpable, and the most destitute internally of any similarity to crystallization, are probably composed of crystalline grains. An examination of Chalcedony by means of polarized light, by Sir David Brewster, has proved this to be true with respect to this mineral, and few species occur which appear to the eye more

perfect specimens of a complete absence of crystallization. Indeed, what is still more remarkable, according to Sir David Brewster, "the phenomena of polarization have proved that the jellies of oranges and gooseberries are really crystallized, and that they even possess double refraction."* We, consequently, shall include under the above head, all the remaining varieties of structure in the mineral kingdom. The only certain exceptions are liquids and gases, and these are so few, and require so few remarks, that a separate caption for them is thought unnecessary.

The individuals composing imperfectly crystallized individuals, may be

1. *Columns*, or *fibres*, in which case the structure is *columnar*.
2. *Thin laminæ*, producing *lamellar* structure.
3. *Grains*, constituting the *granular* structure.

1. *Columnar Structure.*

61. A mineral possesses the columnar structure, when it is composed of elongated columns. These columns vary much in their relative situation, and produce several varieties of the columnar structure.

Fibrous; when the columns or fibres are parallel. Ex. gypsum, asbestus.

Reticulated; when the fibres, or columns, cross in various directions, and produce an appearance having some resemblance to a net.

Stellated, or *stellular;* when they radiate from a centre in all directions, and produce a star-like appearance. Ex. stilbite, gypsum.

Radiated, *divergent;* when the crystals radiate from a centre, but not, necessarily, so as to produce stellar forms. Ex. quartz, gray antimony.

Globular, *reniform;* when, by radiating from a centre in every direction, a spherical, hemispherical, or kidney-shaped form is produced. When attached as they usually are to the surface of a rock, these are described as *implanted globules*. If the surface of the globular masses is rough with minute terminations of small crystals, it is described as *drusy*. This term is also applied to other varieties of structure, with surfaces similarly roughened by crystallization.

Botryoidal; when there is a tendency to radiation from a centre, and the surface formed, is covered with rounded prominences. The name is derived from the Greek, βότρυς, *a bunch of grapes*. Ex. hæmatite, Chalcedony.

Mammillary; resembles the botryoidal, but is composed of larger prominences.

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* Brewster's Ed. Jour. Vol. 10, p. 28.

The fibres are described as *filiform* or *capillary*, when very slender and much elongated.

Stalactitic; when the fibres radiate from a central column.

This term is generally applied to minerals of a certain mode of formation rather than peculiarity of internal structure. Those forms are called stalactites which have been produced by the percolation of water, holding in solution some mineral matter, through the rocky roofs of caverns, or, it may be, small cavities. The evaporation of the water produces a deposit of the mineral matter, and gradually forms a long pendant cylinder or cone. The internal structure may be perfectly crystalline, or may consist of fibres radiating from the central column. Carbonate of lime is the principal mineral that presents the above forms. It is observed also in Chalcedony, Gibbsite, brown iron ore, and many other species.

2. *Lamellar Structure.*

62. The structure of a mineral is lamellar, when composed of plates or leaves. The laminæ may be curved or straight, and thus give rise to the curved lamellar, and straight lamellar structure. Ex. tabular spar, some varieties of gypsum, talc, &c.

3. *Granular Structure.*

63. The granular particles of composition differ much in their size. When very coarse, the mineral is described as *coarsely granular*; when fine, as *finely granular*; and if not distinguishable by the naked eye, the structure is termed *impalpable*. Examples of the first may be observed in granular carbonate of lime, colophonite, the coccolite variety of pyroxene; of the second, in some varieties of specular iron; of the last, in Chalcedony, opal, and most of the mineral species

The above terms are indefinite, but from necessity, as there is every degree of fineness of structure in the mineral species, from the perfectly impalpable, through all possible shades, to the coarsest granular.

Globular and reniform shapes are occasionally presented by minerals of a lamellar or granular structure.

SECTION II.

CRYSTALLOGENY.

64. The following remarks on Crystallogeny, or the formation of minerals, will be distributed in two sections.

1. The theoretical part, in which will be considered the various theories which have been adduced to account for the structure of crystals, and a particular account of that which appears to be most consistent with observed facts.

2. The practical part, including the different processes of crystallization and the attendant circumstances.

CHAPTER I.

THEORETICAL CRYSTALLOGENY.

THEORIES OF VARIOUS AUTHORS.

65. The question naturally arises in the mind of the student of nature, what are the laws by which molecules are superimposed on molecules in perfect order, and these tiny yet wonderful specimens of architecture constructed? What is this crystallogenic attraction? What the nature of the ultimate particles of matter?

Speculations on these subjects have displayed the ingenuity of men of science in various ages of the world. The Grecian philosophers, to account for the various phenomena in nature, imagined these ultimate particles or atoms to be at different times, "round, oval, lenticular, flat, gibbous, oblong, conical, smooth, rough, quadrilateral,"[*] and, to afford these atoms the means of uniting in the production of compounds, provided them with hooks. Such crudities are evidence of the utter futility of studying material nature, in the same manner as immaterial, relying on thought—aided, it may be, by the sensations, but unassisted by any inquiries into the nature of matter itself—for a knowledge of the qualities of matter. The investigations of modern times have not, indeed, answered the query, what is this plastic power in nature; but they have led philosophers to be satisfied with calling it by the general appellation, *attraction;* a term rather expressive of the fact, that the particles combine, than explicative of the nature of this power.

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[*] Epicurus.

This subject lay uninvestigated, and possibly unthought of, from the times of the ancient philosophers till the 13th century.[*] From the 13th to the 17th century, appeared Albertus Magnus,[†] Agricola,[‡] Cæsalpinus,[§] Boetius de Boot,[‖] Baptista von Helmont,[¶] Christian Huygens,[**] Boyle,[††] and many others, who advanced various hypotheses as to the *seeds* of crystals, their *generation*, &c. But, excepting Huygens, who, in a very recondite treatise first developed the doubly refracting nature of Iceland spar, and inferred that its elementary particles were spheroids to account for this peculiar refraction, none made any real improvements on the speculations of their predecessors.

With Nicolaus Steno, towards the latter part of the 17th century, commences a new era. This author examined minutely, the different forms of several minerals and accurately described them. He also first noted the important fundamental fact in Crystallography, afterwards rediscovered, that, *although the faces of crystals are subject to frequent variations of form, their inclinations remain constant.*[‡‡] In the commencement of the 18th century, Gulielmini published on the crystallizations of the salts, where he advanced another principle equally fundamental, that *cleavage in crystals of the same substance yields constantly the same forms.* Gulielmini was led, by these observations, to the same conclusions as the Abbé Haüy, namely, that the elementary corpuscles of bodies possessed those simple forms which may be obtained from crystals by cleavage.[§§] He, however, neglected to extend his investigations on this subject, and left to Romé de Lisle and Haüy, the honor of founding the *science* of Crystallography.

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[*] Many of the following facts have been cited from a valuable work on the history of Crystallography, by Dr. C. M. Marx, entitled, *Geschichte der Crystallkunde*, 314 pp. 8vo. Carlsruhe und Baden. 1825.

[†] De Mineralibus et Rebus Metallicis. 12mo. Colon. 1619.

[‡] De Ortu et Causis subterraneorum. Basiliæ. 1657. fol.

[§] De Metallicis Libri Tres. Norībergæ. 1602. In Book II. 19, he says: "Relinquitur igitur ut sola hexagona fiat, sola enim perfecta est, quia fit ex triplici divisione superficiei ad angulos acutos, sex triangulis in unum veluti centrum coeuntibus, ut omnes anguli externi majores sint recto, ideo ad circuli naturam prope accedunt."

[‖] Gemmarum et Lapidum Historia, quam olim edidit Anselmus Boetius de Boot, postea Andr. Tollius. Lugd. Bat. 1647.

[¶] In a work published in German at Sulzbach, in 1683, he subscribes to the opinion, that the different crystals, like plants and animals, proceed each from its own peculiar seeds.

[**] *Christ. Huygenii* Op. Vol. I. Amst. 1728. 4to. Tractatus de lumine.

[††] *R. Boyle*, Specimen de Gemmarum Origine et Virtutibus. Colon. Allobr. 1680. 4to. P. 6, we find, "Reperiebam in solida lapidis massa cavitates, quarum latera undique circumdederant concretiones, quæ cum essent pellucidæ instar crystalli et elegantissime figuratæ, (calcareous spar?) videbantur fuisse *succus lapidescens* purior, qui tandem percolatione quadam per substantiam crassioris lapidis penetraverat in illas cavitates, et postquam evaporassent superfluæ et aqueæ partes, aut imbibitæ fuissent a vicino lapide, poterant concurrere in pura illa crystalla.

[‡‡] *Nic. Stenonis*, Dissertationis Prodromus de Solido intra Solidum naturaliter contento. Pistorii. 1763.—(first published at Florence, 1669, also, in the Collect. Academ. de Dijon. Partie etrang. T. IV. p. 383.)

[§§] De Salibus Dissertatio epistolaris physico-medico-mechanica conscripta a *Dominico Gulielmini.* Lugd. Bat. 1707. 8vo. p. 2. Determinatam figuram non ab universali aut particulari architectonico spiritu, non a propria innominata forma, sed a

Several writers on these subjects appeared during the half century following Gulielmini; but they made no essential additions to facts.—The theory of tetrahedral atoms was advanced by Ludwig Bourguet.[*]

J. Woodward, an English author, makes quartz crystal the source of all crystallizations, concerning which, he thus expresses himself in his treatise on his collection of "English Fossils,"[†] p. 146: "There is in all spar more or less crystal, which renders it more or less diaphanous," &c. Again, p. 220: "Crystal, pure and without mixture of other matter, concretes even into an hexagonal figure, pyramidal or columnar, terminating in an apex or point. Mineral or metallic matter concreting with it, frequently determines it to other figures peculiar to the disposition of each kind of that matter. *Iron* concreting with crystal, determines it to a rhomboid figure; *tin*, to a quadrilateral pyramid, *lead*, to a cubic."

Somewhat similar was the opinion of Linnæus, who supposed that all crystals contained a salt, and to this owed their crystallization.[‡] This theory obtained considerable credit at that time. We find it clearly expressed in the Philosophical Transactions for 1749, p. 250, by W. Borlase, "'Tis by the force of *salts* that liquid bodies are thrown into all the geometrical planes, angles, and more compounded shapes, the variety of which is no less surprising, than the constancy and uniformity of each particular species." The discoveries in chemistry soon dissipated these views, and at last established philosophers on this settled ground, that the power of crystallization is naturally and independently inherent in all inorganic matter.

Immediately preceding the commencement of the Abbé Haüy's very successful scientific career, appeared Bergman, Werner, and Romé de Lisle. Bergman has the honor of discovering the primary forms of crystals, and Romé de Lisle, that of first measuring their angles, and thus rendering crystallography subservient to the purposes of the mineralogist.

Haüy seems to have entered on his studies with an entire ignorance of the investigations of Bergman and Gulielmini, and in all his observations was an original investigator. A mere accident,

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primarum particularum schemate unice esse derivandam. P. 10; corpuscula insectilia, terminata planis superficiebus ita ad invicem inclinatis, ut simplicem aliquam includent figuram. P. 19; figuris non omnibus, quæ possibiles sunt, utitur natura, sed certis quibusdam tantum, quarum determinatio non est a cerebro eximenda, aut a priori probanda, sed ab experimentis et observationibus desumenda.

[*] *L. Bourguet*, Lettres philosophiques sur la formation de sels et de cristaux. Amsterd. 1729. 8vo.

[†] An attempt towards a natural history of the fossils of England, in a Catalogue of the English Fossils in the collection of *J. Woodward*. 2 vols. Lond. 1728-9.

[‡] Systema Naturæ. ed VI. p. 160. Crystallus lapidea sal non est, sed continet sal, cujus figuram gerit, omnis enim crystallizatio ex sale, &c.

the dropping of a crystal from his hands, and its fracture in consequence, exhibited to him the rhombohedral particles of carbonate of lime. He was thus induced to commence his investigations, and with his philosophic mind soon arrived at general conclusions as to the primary forms.—An obvious theory as to their structure, *that* already proposed by Gulielmini, though unknown to Haüy, was the next result of his investigations. The primary cube he imagined to be constituted of cubic molecules, for cubes and cubes only, can be obtained by mechanical division. Similarly, the rhombohedron was formed of rhombohedral molecules.

Investigations, with respect to the situation of secondary planes, and the laws which govern their formation, gave the Abbé, what appeared to be, additional proof of the correctness of this theory. He discovers, that the formation of secondary planes on the edges of crystals, may be imitated by composing a primary of its molecules, and dropping one row, (or, in his phraseology, by a decrement of one row,) of particles, in each direction, as in fig. 132, or, two rows in one direction, and one in the other, (fig. 133,) or, three rows in the first and one in the second, or, in some other simple ratio: also, that planes on the angles may be formed either by dropping a single row in each of the three directions about an angle, which he calls, (as also in the first case above,) his *simple decrement*, and may be expressed by the ratio 1 : 1 : 1; or by the ratio 1 : 1 : 2, that is, two in height, and one in each of the other directions; or the ratio 1 : 1 : 3, or 1 : 1 : ½. These, and a few other simple ratios, would form all actually occurring planes on angles. These splendid results proved, that the science of Crystallography was founded on a sure mathematical basis, at the same time, that they apparently afforded very convincing evidence of the truth of Haüy's views of the structure of crystals, and the nature of their molecules.

It however appeared to be a difficulty, that cleavage was in some instances, obtained parallel to two primaries at the same time. The rhombic prism, besides its rhombic cleavage, admitted of cleavage parallel to its diagonal, thus dividing it into two three sided prisms. Again, the octahedrons could not be composed of octahedral molecules except by leaving large spaces, to fill which, tetrahedrons were necessary. The Abbé Haüy surmounted the first difficulty, by supposing the molecules to be composed of still simpler solids, which he called integrant molecules. These are the tetrahedron, the three sided prism, and the parallelopiped.

The second difficulty however remained, and could only be surmounted by the improbable hypothesis of two nucleal solids, an octahedron and a tetrahedron.

Its difficulties lay unremoved, when Dr. Wollaston brought forward his very ingenious views on the spherical forms of the molecules of bodies, in the Philosophical Transactions for 1813. It is easily conceived, that many of the primary solids in Crystallography may be formed by the regular aggregation of spheres. Two four sided pyramids of shot, similar to those frequently seen in arsenals, placed base to base, form the regular octahedron, (fig. 134.) If to the octahedron, two three sided pyramids (tetrahedrons, fig. 136,) are added, one on each of two opposite faces, a rhombohedron is formed, (fig. 135.) A rhombohedron of this kind is easily obtained in the cleavage of fluor spar; it is reduced to the octahedron by separating two tetrahedrons.

Rhombohedrons, however, occur of various angles. To obtain these, it is only necessary to suppose the particles of other rhombohedrons to be spheroids, instead of spheres; spheroids are also his molecules of the prisms. The formation of the cube is illustrated by Dr. Wollaston, as follows: "Let a mass of matter be supposed to consist of spherical particles, all of the same size, but of two different kinds in equal numbers, represented by black and white balls; and let it be required that, in their perfect intermixture, every black ball shall be equally distant from all surrounding white balls, and that all adjacent balls of the same denomination shall also be equidistant from each other. I say, then, that these conditions will be fulfilled, if the arrangement be cubical, and that the particles will be in equilibrio." He had previously stated that "a cube may evidently be put together of spherical particles, arranged four and four above each other; but this is not the form which simple spheres are *naturally disposed* to assume, and, consequently, this hypothesis alone is not adequate to its explanation."

This theory, in simplicity, is in some respects far superior to that of the Abbé Haüy. Instead of several different forms, as integrant molecules, and a distinction between proximate and integrant molecules, Wollaston's theory supposes the existence of but one varying solid, the spheroid—of which the sphere is properly a variety—and this hypothesis is found fully sufficient for the production of every form presented by inorganic nature.

But, we regret to say, that this theory, in some particulars, manifests that it received very sparingly the attention of the philosophic mind of Dr. Wollaston; and we regret it, because Wollaston, if any one, was able to have determined the true principles of crystallogeny. The cube and rhombohedron are similar solids, differing merely in that the latter is oblique. It is surely improbable, then, that so different should be their atomic arrangements as Dr. Wollaston's theory supposes; or with reference to the cube alone, that its formation, or even the explanation of it, should require the presence of two kinds of particles? The inquiry also still remains, What is the power which aggregates these spherical molecules in forms so regular, bounded by planes so constant in their interfacial angles? Why is the aggregation of spheres represented in the octahedron, (fig. 134,) more than any other the "*natural grouping*" of molecules?

Other theories have been proposed on this subject; but they seem wholly inadequate to explain the various phenomena.

Without considering farther the history of the science of Crystallogeny, I will proceed to an exposition of what appears to be the true nature of the molecules and molecular action in the formation of crystals; and, in treating of this subject, I shall first examine into the forms of the crystalline molecules, and the nature of crystallogenic attraction;[*] second, the laws by which the molecules aggregate themselves in the construction of the primary solids; third, the formation of compound crystals; fourth, the formation of secondary planes: fifth, the influence of extraneous causes, producing distorted crystals, and aggregated crystallizations.

THE NATURE OF CRYSTALLINE MOLECULES.

66. By *crystalline* molecule, is understood, the molecule in the state peculiar to it, when about to enter into the constitution of a crystal, or when a constituent part of a crystal. Evidently, some important change is effected in the molecules at the time of crystallization. The moment before, they lay in close connection, but perfectly regardless, if I may so express myself, of each other. But in the act of crystallization, they unite almost instantaneously, and are firmly compacted in the hard unyielding crystal.

Forms of Molecules.

67. We adopt, in part, Wollaston's theory of spherical and spheroidal molecules, and suppose the molecule of each primary to be that spheroidal body, or ellipsoid, which described within the prism, touches the centres of its faces. These molecules, by their aggregation, must produce the same forms as proceed from the aggregation of Abbé Haüy's polyhedral molecules; that is, they should have the same proportional height, breadth, and thickness, or otherwise they will not, by combination, produce a primary form of the same dimensions. To explain farther, the molecule of a right rectangular prism must have the same relative length, breadth, and thickness, as this primary; else a right rectangular prism of these particular dimensions will not be formed by a union of its molecules.

We may therefore lay down this principle, an *ellipsoid*[†]—*which,*

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[*] The following views on crystallogeny, were first read before the Yale Natural History Society, March 3, 1836, and published in Volume XXX. p. 275, of the American Journal of Science, in an article on the Formation of Compound or Twin Crystals.

[†] The following remarks are made in explanation of the solids, termed ellipsoids, or solid ellipses, and their conjugate axes and diameters.

AA′ BB′, is a plane ellipse. A′B′, AB, two lines crossing at right angles, are termed its *conjugate axes; a′b′, ab,* its *conjugate diameters.* The relative situation *described within the prism, touches the centres of its prismatic faces, is the elementary molecule of this prism*; or, in perhaps clearer language, it is the largest ellipsoid that can be placed within Haüy's prismatic molecule, having the same height and other dimensions.

Crystallogenic Attraction.

68. The ordinary attraction of cohesion has been considered an adequate cause of the union of molecules in the production of the regular crystal. This attraction acts, however, in every direction from the centre of the particle, and, consequently, will cause an addition of particles in no fixed direction, and therefore will invariably produce a spherical solid. Proof of this fact is observed in every drop of water, or globule of mercury, whose spherical forms result from the influence of this kind of attraction. To produce solids, bounded by a definite number of surfaces, there is required a definite number of directions for the exertion of the attraction. If attraction is exerted in but one direction, the particles will unite only in this direction, and by their union will form only a single line of spheres: exertion in two directions will, in a similar manner, produce a figure of two dimensions only, that is, a plane; in three directions, a figure of *three* dimensions, or a solid bounded by six faces, as the cube. For the formation of the prisms, it is therefore necessary that the mutual attraction of the particles be exerted in three fixed directions in each molecule.

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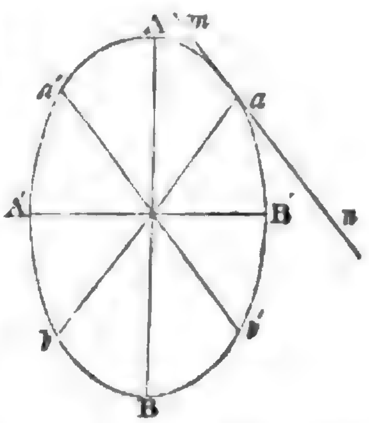
of these *conjugate diameters* is such, that if a line, (*mn*,) be drawn, touching the ellipse at *a* the extremity of one diameter *ab*, it will be parallel to the other *a′b′*. When *ab* and *a′b′* are equal, they are termed the *equal conjugate diameters*; when they intersect at right angles, they are, as stated above, the *conjugate axes.*



The revolution of a plane semi-ellipse, AB′B, around one axis, describes the surface of a solid, which is denominated an ellipsoid of revolution. Let the semi-ellipse AB′B, revolve on AB as an axis, all the sections of the described solid, passing through AB, will be ellipses, of the same curvature as the above plane ellipse, their curvature being determined by that of AB′B. Again, as every point in the curve AB′B, describes a circle in its revolution about AB, the sections parallel to the plane described by A′B′, or at right angles with AB, are circles, and, consequently, the lateral axes which lie in the section A′B′, are equal. The ellipsoid of revolution has, therefore, its sections in one direction, *circles.* If these sections are ellipses, the solid is still an *ellipsoid*, but *not one of revolution*, as the simple revolution of a plane ellipse will not describe it.

The axes of ellipsoids are three, and intersect at right angles. The three conjugate diameters are any lines so drawn that a plane touching the ellipsoid at the extremity of one, is parallel to the plane in which the other diameters are situated. Each face of a prism, which touches the ellipsoid at the extremity of one crystallogenic axis, is necessarily parallel to the plane in which the other two axes are situated, (figs. 1, 3, 7.) Consequently, the crystallogenic axes, (lines connecting the centres of opposite faces,) are always the conjugate diameters of the ellipsoid, and, if they intersect at right angles, are called conjugate axes.

69. These fixed directions may be denominated axes, and their extremities, poles, the one *north*, the other *south*. In each instance, the axes connect the centres of the faces of the prism; for action in these directions only can produce solids similar to the prisms.

a. Cube. The crystallogenic axes of the cube are three equal lines intersecting at right angles, and hence the molecule is a sphere, with three equal conjugate axes, as axes of attraction, (fig. 1, Pl. III.)

Influenced by these axes, the spheres will combine as in fig. 2, and a cube will be formed in the same manner as by the aggregation of an equal number of cubes.

b. Rt. Square Prism. The length of this prism being unequal to its breadth, and its breadth and width equal, the same must be true of the molecule, and consequently it is an *ellipsoid of revolution*, (fig. 3.) Its lateral axes are equal to one another but unequal to the vertical, and intersect at right angles. The axes of these molecules have thus a situation similar to those of the cube, and by their action will form a solid differing from the cube only in its varying height, that is, a *Right Square Prism.*

c. Rt. Rectangular Prism. This solid has three unequal dimensions, and therefore the three conjugate axes of the molecule are unequal, and the horizontal section is an ellipse. The molecule therefore is *not* an ellipsoid of revolution. Fig. 4, is a transverse section of the prism and ellipsoid.

We may consider the molecule of the cube an ellipsoid with three *equal* axes, that of the right square prism, an ellipsoid with but two of its axes equal, and that of the right rectangular prism, an ellipsoid with three unequal axes.

d. Rt. Rhombic Prism. Fig. 5 exhibits a horizontal section of this prism and its molecule. The molecule is similar to that of the rectangular prism, but its axes, which connect the centres of the opposite faces, are obliquely inclined, and being *equal*, are the *equal* conjugate *diameters*, instead of its *conjugate axes.* The vertical axis, as in the preceding prisms, is still one of the conjugate *axes.* The same is the fact with the

e. Rt. Rhomboidal Prism. Its lateral axes are however *unequal*, (fig. 5,) and may be any unequal conjugate diameters of the ellipsoid, at right angles with the vertical axis.

f. Rhombohedron, Oblique Rhombic and Rhomboidal Prisms. In the oblique prisms, the vertical axis is inclined, and is not therefore one of the conjugate *axes*, but a conjugate diameter to either of the lateral axes, which are also conjugate diameters. The lateral conjugate diameters are equal in the rhombic, but unequal in the rhomboidal prism. In the rhombohedron, the lines connecting the centres of opposite faces are equal, and consequently the ellipsoid is one of revolution, and the three crystallogenic axes, its *equal conjugate diameters*, figs. 7, *a*, and 7, *b*. The dotted letters in the above figures are supposed to be situated on the back faces.*

70. A comprehensive view of the molecules and their axes is given in the following table.

Prisms, all of whose cryst. axes intersect at *right* angles, and are therefore conjugate *axes* of the ellipsoidal molecule	axes equal—*Cube.*
	two only equal—*Rt. Square Prism.*
	the three unequal—*Rt. Rectang. Prism.*
Prisms whose *lat.* axes are obliquely incl. and are therefore conj. diam. (not axes) of the molecule	lat. axes, *equal* conj. diam.—*Rt. Rbc. Prism.*
	lat. axes, *unequal* conj. diam.—*Rt. Rbdl. Prism.*
Prisms, all of whose axes intersect at *oblique* angles, and are therefore conj. diam. (not axes) of the molec.	the three axes, equal conj. diam.—*Rhombohedron.*
	two lateral axes, eq. conj. dia.—*Ob. Rbc. Prism.*
	the three axes, uneq. conj. di.—*Ob. Rbdl. Prism.*

From this table it is apparent, that all possible positions of these diameters occur in the forms of crystals, from an equality and rectangularity in the cube, through different variations in length and situation, to a general inequality in length, and a like inequality in their mutual inclinations, as in the oblique rhomboidal prism.

Moreover we perceive that all the prismatic primaries, may proceed from one simple solid, an ellipsoid, (a sphere being an ellipsoid with equal rectangular axes,) and all may result from a variation merely, in the length and direction of the conjugate diameters of this solid. The simplicity which this view of the subject gives to the whole science of crystallography, is obvious.

71. With respect to the primary octahedrons and dodecahedrons, it is probable that the regular octahedron and dodecahedron are formed from the axes of the cubic molecule, so modified as to produce a cleavage parallel to their primary faces: also that the other octahedrons contain the same molecule as the prisms of the same bases. It has already been remarked that the right rhombic prisms often admit of cleavage parallel to one of the diagonals. A similar occurrence in the cube would give rise to a rhombic dodecahedron as the result of cleavage.

72. It has been stated that the axes of attraction have polarity. We have not the means as yet of determining in every instance which are the North, and which the South poles of a crystal. It may however be inferred with reference to the rhombohedron, that the three poles about each vertical solid angle are of the same name, those about one, *North*, and those about the other, *South*. In crystals of turmaline there is then some correspondence between the crystallogenic poles and those induced by heat. Probably also in the oblique prisms, the poles about a dominant solid angle are of the same kind. It is also probable that the poles about

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* The Rhombohedron thus formed differs materially from that proposed by Wollaston, (fig. 128.) The molecules influenced by these axes, will produce an arrangement similar to that in the cube and other prisms.

an acute edge in the right prisms are of the same kind, as marked in fig. 5. Farther than this, it is impossible to distinguish the poles of the axes in the different primaries.

LAWS GOVERNING THE CRYSTALLINE MOLECULES IN THE FORMATION OF THE PRIMARY SOLIDS.

73. The molecules of matter in the act of crystallization, are influenced by the usual principles of attraction, *the repulsion of like poles and the attraction of unlike*, that is, two norths or two souths repel, a north and a south mutually attract. There is this peculiarity however, that *only the unlike poles of similar axes will unite.* An attraction exists between the north pole of the vertical axis of one molecule, and the south pole of that of another; but none between the north of the vertical axis and the south of a lateral, when the lateral and vertical are unlike axes. No reason can be required for a fact which appears to be so natural a deduction from the general nature of attraction. We should rather be astonished if the fact were otherwise. It also proceeds from the nature of this attraction, that similar axes will by their union form a straight line; that is, will unite as in fig. 9, Pl. III, and not as in fig. 11.

The most probable hypothesis of the process of crystallization appears to be the following: At the time of crystallization, the molecules, leaving the spherical form of the fluid state, (unless the crystalline molecule is a sphere,) assume their ellipsoidal forms, and cotemporaneously their crystallogenic axes. These forms and axes depend on the nature of the elements in the crystallizing compound. Instantly on the assumption of these axes, the union commences. The molecule which first assumes its form, becomes the nucleus, around which those subsequent in their formation aggregate according to the above laws. The result is one of the regular geometrical solids of crystallography.

FORMATION OF COMPOUND CRYSTALS.

1. *Connatal Compound Crystals.*

74. The mutual influence of the molecules causes them to assume the parallel position of fig. 9, unless some peculiar circumstances operate to prevent it. During the formation of the myriads of crystals which are produced at every process of crystallization, it must be no uncommon occurrence that two molecules, assuming simultaneously their axes, should be situated in close proximity, and in the position given in fig. 10, Pl. III. A north and south pole are here adjacent, as in fig. 9; but a north pole of one of the axes of one molecule, has the direction of the south pole in the other molecule. There is a natural tendency to an inversion of one molecule, in order that the joining axes may be in the same straight line; but this tendency is far inferior to the strong attrac-

tion exerted between the adjacent north and south poles. The molecules therefore unite as in fig. 11, and constitute, by their union, a nucleus, each half of which acts independently of, though in connection with, the other, and thus produces a compound crystal. To this accident is owing the formation of *compound crystals of the first kind*, (§ 57,) or those in which composition has taken place parallel to the primary faces. Fig. 13, Pl. III, represents a crystal of Arragonite thus formed, and fig. 13, *a*, a horizontal section of the same. The planes ĕ, ĕ, truncate the acute lateral edges, as may be observed in fig. 13, *b*.

It is obvious that the axes of the molecules, which are at right angles with those represented in the figure, (and therefore since they point towards the observer, cannot be represented,) may present their similar poles in the same direction, or by the inversion of one molecule, opposite poles may point in the same direction, as is the case with the parallel axes in the figure. There are therefore the above two methods of forming compound crystals of *the first kind*. In the *right* rhombic prism, however, both these methods produce the same result, as it matters not whether we invert one of the prisms, (fig. 130,) as described in § 57, or whether we change the lateral face, by which one is united to the other, without inversion; that is, apply the face M, of the right hand prism, instead of the one which is now in contact, supposing the polarity of the former plane to be the same with that of the latter. The same form is produced by both methods. But in the *oblique* prisms the difference of structure is very apparent. The figures of the peculiar compound crystals of feldspar, given in connection with the description of that species, are representations of forms resulting by the first method: the *similar* poles of the vertical axis lie in the same direction. A figure of a twin crystal of albite, (see the description of the species albite,) represents a compound form produced according to the second method in which *opposite* poles of each pair of axes are pointed in the same direction.*

We here perceive that those accidents, to which molecules governed by axial attractions are necessarily liable, actually take place in nature; and they afford strong presumptive evidence of the truth of the theory proposed to account for them. Did they not occur, we might very properly conclude that the crystalline molecules were governed by some other force distinct from attraction in fixed directions or axial lines.

75. In the formation of other compound crystals, two molecules unite in points of equilibrium of attraction between *two* poles, and thus give rise to twins of the *second kind*; or in similar points be-

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* The primary form of feldspar, we have supposed, with Haire, to be an oblique *rhomboidal* prism. If the oblique *rhombic* prism is considered the primary, which would be inferred from its secondary planes, the composition is of a similar nature, but is of the *second* kind.

tween three poles, producing twins of the *third kind*. In the first case, the situation of the molecules is, as given in fig. 12, Pl. III, where they are retained in combination by the action of two north poles of one molecule, on the two south poles of the other. It is obvious that this is an instance of composition parallel to an edge, as the edges in the primary forms, lie opposite the point of equilibrium of attraction between two poles. This is shown by the rectangular figure described about the molecule.

In the second case, the combination is due to the action of three poles of one molecule on three opposite of the other, and consequently the composition is parallel to a plane on an angle.

These accidental forms may also be considered a consequence of the nature of the attraction. In the action of particles on one another, assuming, at the time, their crystallogenic axes, it is not improbable that two molecules should unite elsewhere than at their poles, provided their mutual attractions remain balanced.

An example of the second kind of twins is given in fig. 14, Pl. III, which represents a crystal of pyroxene compounded parallel to the edge ĕ. The third kind is exemplified in figs. 15 and 16, the former a delineation of a crystal of manganite, the latter a scalene dodecahedron of calcareous spar. The composition in this last instance is effected parallel to a plane truncating the vertical angle, or in the point of equilibrium between the three north poles of one molecule, and the three south of the other.

76. Compound crystals composed of more than two individuals, arise from the occurrence of the above species of composition parallel to two or more faces, edges or angles, simultaneously. Several of these forms are represented in figs. 3, 5, 6, 8, Pl. IV.

Fig. 1, represents a horizontal section of a crystal of white lead ore, four of whose lateral angles equal 117° 14′, the obtuse angle of the primary rhombic prism, and two equal 125° 32′, twice the acute angle of the same. In this instance, (fig. 1,) composition of the first kind has taken place parallel to two faces of A. The prism which would thus obtain, is identical in its interfacial angles with those of the crystal under consideration, as a simple calculation will show.

Fig. 2, is a horizontal section of fig. 3, (another crystal of the same mineral,) whose lateral angles are given in fig. 2. Composition of the first kind has here taken place between A and B, and subsequently, though almost consentaneously, C was added by the attractions between the poles represented in contact. In the preceding prism, (fig. 1,) the union of B and C with A was effected at the *same instant*, but here the addition of C was *subsequent* to the union of A and B, and from this has arisen the equal inclination of C to the other molecules.

A horizontal section of fig. 6, a crystal of Witherite, is exhibited in the outer lines of fig. 4. This prism differs from the preceding in the disposition of its primary angles, which are lettered, *a*, *b*, *c*, *d*. The angles *m* and *n*, each equal twice the acute angle. To form the nucleus, AB and CD were first united, and subsequently the compound nuclei AB CD, were joined by the action of the axes, which are now represented as nearly in contact. This union is stated to be a subsequent act, but though this was probably the case, the whole was undoubtedly accomplished in a shorter instant than it is within the compass of the human mind to imagine.

When the lateral edges of the component prisms are truncated, as in fig. 13, Pl. III, the cruciform crystal in fig. 5, Pl. IV, is produced, of which a section is given in fig. 4. A similar truncation reduces fig. 1 to the stellated figure represented in it.

In fig. 7, a compound nucleus is represented, in which composition of the first kind has been effected parallel to all the lateral faces of the molecule A. The truncation of the lateral edges of the four crystals, B, C, D, E, would give rise only to a cruciform crystal. But the action of the central molecule A, together with that of the poles *m*, *n*, will cause an addition of particles parallel to A, and thus give rise to the other rays. This is a horizontal section of fig. 8, a crystal of white lead ore.

Compound crystals of *the first kind* are of much the most frequent occurrence in the rhombic prisms, and especially when the lateral angle equals nearly 120°; and if exactly 120°, as is the fact with snow, *simple* crystals are seldom observed. Three molecules, whose lateral axes are inclined at an angle of 120°, form by their union a perfectly compact group, similar to fig. 1, Pl. IV, except that all their axes are united in close contact; and consequently their mutual action produces almost necessarily this compound structure. The three, so to speak, will not permit one another to govern by becoming a nucleus, and therefore they unite and act conjointly. The union of six molecules by their acute angles, may also take place in the same manner, (fig. 13, Pl. IX,) for 6×60°, (60° is the value of the acute angles when the obtuse are 120°,) equals 360°. This arrangement is probably the origin of most of the stellated crystallizations of snow. Rhombic prisms, whose angles vary much from 120°, seldom present this species of compound crystal. There is one exception to this remark in the case of white iron pyrites, the lateral angles of whose rhombic prisms equal 106° 2′. But this exception beautifully illustrates the general principle. These crystals are composed of five simple crystals, and the angle 73° 58′, (the acute angle of the prism,) is about *one fifth* of 360°. The occurrence of these forms, therefore, corroborates the principle included in the above statements.

77. In the same manner composition may take place simultaneously parallel to *more than one edge or angle*. The crystals of harmotome are examples of the former. The primary of this mineral is a right rectangular prism, and the relation of this solid to the rhombic prism is such, that explanations, additional to those above given are unnecessary.

It is an important fact, that those rectangular crystals are more frequently compounded, whose planes, replacing the four lateral edges, incline to one another nearly at angles of 120° and 60°. Such is the case in chrysoberyl.

2. *Postnatal Compound Crystals.*

78. Postnatal crystals are described in § 19, to be of two kinds.

1. Doubly geniculated crystals, or those which have been apparently *bent* subsequent to their formation.

2. Those which are composed of two distinct crystals, united by their similar parts.

The former species of compound crystal, result from a reversion of the original polarity in the molecules of the crystal, after the crystal has attained some size. The causes of this reversion are, probably, agents that are not unknown to us. Heat will have this effect on crystals of turmaline, their polarity varying with the temperature. Electricity is equally an efficient agent in producing similar results.

A reference to a figure, will show the capability of this hypothesis to account for these occurrences. Let AB, (fig. 9,) represent a line of molecules in a crystal in the act of formation, with its poles situated as there marked, (the marked poles are north.) The particle C is supposed to be on the point of obeying its axes of attraction, by uniting the pole *n*, with *m*. At this moment there is a sudden reversion of the polarity of the crystal, as exhibited in A′B′. The molecule C, now finds a repellent pole opposing it, since *m* and *n* are both north, and is immediately drawn around by the attraction between *o*, the nearest south, and *m*, and the union exhibited in A″B″C, takes place, producing a geniculation in the crystal. The process, going on simultaneously at the other extremity of the crystal, causes another geniculation of the same. Fig. 11, is a section of a crystal somewhat resembling fig. 13, Pl. III, in which there is seen both a connatal and postnatal composition. The latter was effected as above described. Geniculation, according to the second kind of composition, may be illustrated by means of fig. 10; AB is again the crystal, C the next particle to be added. The molecules are those of a right square prism, which form is peculiarly subject to these accidents. In the figure, these molecules lie on one of their sides, and only one lateral axis is seen, the other directing its north pole, *s*, towards the observer. The union of *m* and *n*, is again prevented by a reversion of the polarity; *m*, therefore, attracts the nearest north pole, which is *s*. A revolution of 90° must hence take place. But during this time, the unlike poles, *t* and *u*, (the vertical of the prism,) are acting on one another and tending towards a union; consequently, the molecule will assume the intermediate position seen in A″B″C, in which contact has taken place at the point of equilibrium between two poles.

A similar composition could not occur in the right rectangular prism; for, *s* could not be united to *m*, they being unlike axes, and consequently, there would be an entire revolution of 180°, to bring *r* to a union with *m*. Such instances may often occur; but it is impossible to detect them. We hence see why the right square prism is more particularly subject to this kind of geniculation.

An explanation of a postnatal geniculation, according to the third kind of composition, is difficult to explain on account of the number of axes engaged, and the consequent difficulty of representing it in a figure. It flows, however, readily from the above. An example of the same is given in fig. 12. If *e* were the primary planes, it would be an instance of geniculation according to the *second* kind of composition.

79. The remaining kind of compound crystal, is represented in fig. 9, of the species *quartz*. It is perfectly analogous to the ordinary union of two molecules; for the crystals are united by their similar parts of opposite polarity, and have their similar faces parallel. They were, probably, brought originally into this parallel situation, by a process analogous to electrical induction, or the mutual action of their attracting influences. We here discover an interesting analogy between electricity and crystallogenic attraction.

FORMATION OF SECONDARY PLANES.

80. When the axes act in their natural state, that is, unmodified in their strength of attraction, the only result is a primary form. The force of attraction in the direction of the axes of any molecule, is inversely proportioned to the lengths of the axes; that is, representing the axes by *a*, *b*, *c*, the force of attraction in the direction of each will vary, as

$$\frac{1}{a} : \frac{1}{b} : \frac{1}{c}, \quad \text{or} \quad 1 : \frac{a}{b} : \frac{a}{c}.$$

If these axes are modified in their attractions, or if the relation between the intensity of attraction and length of axes, is changed, some corresponding change must take place in the form of the solid resulting from their action, or, in other words, secondary planes must be produced.

The laws for the occurrence of secondary planes, (§ 28,) are a necessary sequence, from the very natural principle, that *similar axes must be similarly and simultaneously modified.* The same cause which is effectual in modifying one, must have the same influence on all similar axes. For this reason, all the edges or angles of a cube are simultaneously truncated. Also, the lateral edges of a right square prism are simultaneously truncated; but they are not necessarily accompanied with a replacement of the terminal edges, because this requires, in addition, a modification of the vertical axis, which is unlike the other two, and which therefore is not, of consequence, affected by the same cause. Hence we have the general principle, ***dissimilar parts of a crystal are independently replaced.***

Again, one of two beveling planes is accompanied, (excepting the few instances of hemihedrism,) by the other; for the same cause that will produce a plane inclining towards one of two similar axes, will produce a corresponding one inclining at an equal angle to the other. The same principle requires also six intermediaries on each angle of a cube, and but two on those of the right square prism.

In the rhombohedron, (fig. 7, *a*, or 7, *b*,) the plane truncating the terminal angle, may be considered as touching the molecule at the point of equilibrium of attraction, between the three poles N, N, *N*, or the three S, *S*, *S*, the planes truncating the terminal edges touch the same, in a similar point, between the pairs of N s, or pairs of S s; those truncating the lateral edges, similar equilibrial points between N″, S′; S′, N‴; N‴, *S*″; *S*″, *N*′, &c.; that is, a north pole of one extremity, and a south of the other.

Thus, in all the primary forms, we find a perfect correspondence between the occurring planes and the above principles.

The hemihedral modifications of crystals, do not militate with the general theory, but merely evince that other powers operate on matter besides crystallogenic attraction. From the electrical nature of most of these hemihedral crystals, it may be plausibly conjectured that they owe their peculiarities to electrical influence. Turmalines are, in most instances, hemihedrally modified, (see fig. 4, of the species turmaline,) and as invariably, when heated, exhibit electrical polarity. Boracite is in the same manner electric, when heated. The north pole is invariably the most highly modified with secondary planes.*

DISTORTION OF CRYSTALS AND AGGREGATED CRYSTALLIZATIONS.

81. If the intensity of attraction in the direction of any one axis is independently increased, the addition of particles will take place in the line of this axis, and the crystal will be lengthened in that direction, without any change in its interfacial angles. This occurs independently of the formation of secondary planes, since these require a *mutual modification* of either *two* or *three* axes between which they are situated. Cubes are often lengthened thus into right square or right rectangular prisms, the rhombohedron into oblique rhombic or rhomboidal prisms. Prismatic crystals often shoot out to a great length, when the actual length of the

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* The tetrahedron has not been included among the primary forms, since it is a result of a hemihedral modification of one of the monometric primaries. The irregular tetrahedron which occurs in some copper ores, and is a secondary to the right square prism, might be ranked with the primary forms, with as much propriety as the regular tetrahedron. It evidently proceeds from the same kind of modification in the attraction, that produces the dissimilarly terminated crystals of turmaline, &c.

primary, compared with the breadth, is small. Such are many saline crystallizations.

In general, these crystals are attached to some object, by one of the poles of the lengthened axis, and seem to derive this increase of attracting power from the nature, (electrical ?) of their support. Fig. 8, of the species *quartz*, represents a distorted crystal of quartz, and fig. 2, of calcareous spar, an equally distorted scalene dodecahedron of this species. This form is at present entirely disguised by the undue extension of the crystal in the direction of the axis by which it is attached. The primary faces R, R, together with the planes e', e', the opposites of R, R, and the opposites of e', e', form an eight sided prism, which is terminated by a small plane R''', and the remaining reduced faces of the dodecahedron. The crystal was attached to the rock by the face R, and is consequently lengthened in the direction of the axis which meets this face. Crystals of quartz are usually attached by the three axes about a vertical angle, and therefore arise perpendicularly from their support, sometimes to a great length. An analogous cause will produce crystals which are very short, in the direction of the vertical axes.

The particular pole by which a crystal is attached to its support, probably, depends on the electrical state of this support; and from this cause arises the regularity with which crystals are often aggregated.

Fibrous crystallizations have a similar origin. They usually occur as veins in rocks, where they were formed by the influence of the attraction in the opposite sides of the vein, causing a large deposition of crystals, and their rapid elongation across the vein. Occasionally, they are found on surfaces not having, as veins, a corresponding parallel; then the great rapidity of the crystallization, induced by the electrical influence of their support, has apparently, caused a struggling between the crystals for room, and the consequent formation of closely compacted crystals, or, in other words, the fibrous structure. The fibres composing this structure, when thus formed, are often regularly terminated.

ISOMORPHISM.—DIMORPHISM.

82. *Isomorphism.*—It is a late discovery in science that, in some instances, one element may replace another in a chemical compound, without changing the crystallization. Potash and ammonia, combined with the same acid, have the same primitive form. These are termed *Isomorphous* bodies by Mitscherlich, the principal investigator of these facts. This property has been supposed to arise, from the similarity in the form and size of the atoms of the isomorphous bodies. It is more probable, that this power depends on the similar crystallogenic relations of these two elements, in

consequence of which, the same axial arrangement takes place in the different compound molecules.

83. *Dimorphism.*—This term is applied to that peculiarity of certain compounds, by which they present entirely distinct crystallizations under different circumstances. Carbonate of lime is thus stated to be a *Dimorphous* compound, since it crystallizes at one time, in rhombohedral crystals, in other circumstances, in secondaries to a rhombic prism; it is called Arragonite, when possessing the latter crystalline form. In Brewster's Edinburgh Journal of Science, vol. vi, p. 301, an interesting account of a change of the system of crystallization of sulphate of zinc, by the influence of heat, is given by Mitscherlich. "When a *right rhombic prism* of this salt is heated above a temperature of 126° F., we may observe certain points at its surface become opaque, and then branches of crystals shoot out from these points in the interior of the original specimen. In a short time, the whole is converted into an aggregate of those crystals, diverging from several centres, that are situated on the surface of the original crystal."

These small crystals, which are formed without any change of composition, were *oblique rhombic prisms*, which form is also obtained when the solution crystallizes above the temperature of 126° F.

Dimorphism, therefore, appears to be owing to the different circumstances attending crystallization. The degree of heat during crystallization, the nature of the solvent combined with some other causes, may effect a change in the direction of the axes and the curvature of the molecules, although, generally, the only effect of these causes is the production of secondary planes. In the instance cited above, heat seems to have been the only cause. The prismatic form of arragonite may be owing to the presence of merely a small quantity of carbonate of strontian in the solvent, which this mineral usually contains, though in a variable quantity.

CHAPTER II.

PRACTICAL CRYSTALLOGENY.

85. An essential preliminary to crystallization, is a perfect freedom of motion among the elementary particles. While in the solid state, the attraction of cohesion is already in action, and prevents any other arrangement than that already possessed by the mineral. But when this cohesive attraction is once overcome, and the molecules are freed from mutual restraint, they are then at liberty to be influenced by the peculiar attraction of crystallization, and under its guidance will assume a crystalline arrangement.

There are two means of counteracting this attraction, or reducing the solid to the state of a fluid, each of which is a frequent source of crystallization, both in the laboratory of nature, and of nature's student, the chemist: They are—1. By solution. 2. By fusion.

CRYSTALLIZATION FROM SOLUTION.

86. The effect of a liquid solvent, as water, upon the dissolving salt, is to separate its molecules, and destroy their mutual attraction, by the attraction of the particles of the liquid for those of the salt. By solution, we pull down, so to speak, the original structure, and separate its constituent stones, preparatory to a rebuilding of the same. The reconstruction we effect, by driving off the antagonist power, *water*, by means of a slowly applied heat producing evaporation. Thus free again, the particles can reassume their power of attraction and their crystalline nature, and in favorable circumstances, will build up the regular crystal.

Crystallization by this means, takes place very differently with different substances. In some instances no appearance of crystallization is apparent till the solution has reached a certain degree of density, when suddenly the whole shoots into a mass of crystals, the water itself entering into their constitution, and forming what is termed the *water of crystallization.*

At other times, after a certain degree of evaporation, the solution, if laid aside to cool, enters the crystalline state as the temperature diminishes.

Often, soon after the commencement of evaporation, small crystals attach themselves to any prominent object in the containing vessel, and continue their increase with the continuance of the evaporation. In the crystallization of other substances, small crystals, as evaporation proceeds, are observed first to float on the surface of the liquid, increasing gradually in size without changing their forms, until from an increase of weight, they sink and attach themselves to the bottom of the vessel. Salt affords frequent instances of this process. A very gradual evaporation sometimes produces singular forms of this mineral. As evaporation goes on only at the surface, there the incipient crystal first appears, a minute cube, which presents under the magnifier well defined angles and plane surfaces. Evaporation continues, and as the cube is in contact with the surface of the solution only along its sides, it enlarges laterally without much addition to its thickness. It now sinks so that only its upper edges are exposed to the surface where the crystalline molecules are forming, and consequently these only receive the addition of particles. With every new increase, it continues sinking, at the same time that the particles are added as continually to the upper and outer edge, till finally the result is an inverted hollow four sided pyramid, which swims like a cup on the surface of the fluid. Fig. 137.

Large isolated crystals of the different salts are usually obtained with difficulty. According to Beudant, they may be produced by causing the crystallisation to take place in a gelatinous medium. The large crystals of quartz, found filling cavities in rocks, seemed to have been formed in this manner.

Any fluid which will act the part of a solvent, may in general be employed for obtaining crystallizations. Alcohol and ether may often be used, and in some instances are the only solvents.

We are acquainted with but few of the solvents employed in nature. Water saturated with carbonic acid, is a common solvent of carbonate of lime, and by this means the stalactites of this mineral are produced. Water at a high temperature, holding soda or potash in solution, will dissolve silica. A large tract of land in Iceland has been entirely deprived of its vegetation, by the deposition of silica from the Geysers of that volcanic country.

But probably in most instances crystals have resulted from the action of the second means of fluidity.

CRYSTALLIZATION FROM FUSION.

87. In this process, heat is the divellent force by which the original arrangement of the particles is destroyed, and that freedom from mutual restraint obtained, which is necessary for crystallization. By a reduction of the temperature, or a removal of the antagonist power, heat, the particles are again permitted to assume their crystalline nature, and their respective positions in the structure of a crystal. Every winter's day affords us innumerable instances of this process, when the removal of the heat which retains water in a fluid state, allows the particles to combine by their mutual attractions, and cover our streams with extended sheets of ice.

To obtain fine crystals by this method, often requires much care. In the case of sulphur, and several of the metals, the most effectual method consists in pouring off the central portion of the fluid mass, soon after a crust has formed by cooling on the surface. Bismuth may, in this manner, be obtained in fine crystals. But this means of crystallization is less within the control of art than the preceding.

Many substances crystallize directly from a gaseous state. The crystalline deposits of sal ammoniac and sulphur, in volcanic districts, are often thus produced. Crystals of specular iron occur at Vesuvius, so light and slender in their leaf-like structure, as to be blown away by a slight breath. In their formation, there was probably a direct transition from the gaseous to the solid state. A more common example is the formation of snow, every flake of which is composed of a congeries of minute crystals. This process takes place when the atmosphere, loaded with vapor, is so reduced in temperature, that the particles are no longer restrained by heat from obeying their own inclinations, or, in more correct language, their attractions.

Crystallization, by each of the above methods, is often attended with an emission of light. In general, at the first effort of crystallization, there appears an instantaneous and often brilliant flash of light, which, in some instances, is repeated at the commencement of each new crystal. Splendid exhibitions of this kind have been observed by M. Büchner, of Magonza,* during the crystallization of benzoic acid; the discharge of light continued for a half hour. Acetate of potash, boracic acid, and many other compounds, and even water, occasionally exhibit this phenomenon.

CAUSES OF SECONDARY PLANES.

88. Beudant, in his Treatise on Mineralogy,† in which this subject has received some attention, states as the principal cause of secondary planes, *the nature of the solvent, and of the substances it holds in solution.*

He remarks, that when the solvent contains, *mechanically* suspended, minute particles of foreign matter, the crystals formed, contain more or less of these foreign particles regularly arranged, either in concentric layers with the laminæ of the crystal, or in the direction of a diagonal, or occasionally intermingled without regular order; and that the crystals thus impure, are *more simple* and regular than those obtained from a clear liquid. Crystals of quartz are seldom perfectly regular bipyramidal prisms, except when they contain large portions of chlorite. But if the solvent contains other substances in *solution*, either solid, liquid, or gaseous, secondary forms are usually produced. "Common salt, crystallizing from pure water, presents, almost invariably, a cubic form. But in a solution of boracic acid, it always occurs with truncated angles," (fig. 2, Pl. I.) The Rev. E. Craig, in an interesting article on Microscopic Chemistry, in the Lond. and Ed. Phil. Mag. and Jour. of Science, July, 1836, p. 13, states the following remarkable transformations in crystals of carbonate of copper, produced by a change in the nature of the solvent, "If sulphuric acid be added to carbonate of copper, crystals speedily appear, presenting the form of six sided tabular prisms. Add a little ammonia, the form is changed entirely to a long rectangular prism with the angles replaced. Add a little more ammonia, and the form changes to several varieties of the rhombic octahedron: a little nitric acid restores again the form of the rectangular prism. In all these successive changes, it is not that a few crystals of another form have been superadded, but each time, the metamorphosis is seen to take place in the whole mass."

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* Brewster's Ed. Jour. III. 369.

† Traité élémentaire de Minéralogie, par F. S. Beudant, 2 vols. 8vo. 1830, 2d ed.; T. I. p. 189.

There are many evidences that the same cause has operated *in nature* to produce the peculiar secondary planes a crystal presents. Arragonite, in iron mines, crystallizes in very acute pyramidal crystals; but in the gypsum clays, accompanying the saliferous deposits, it always appears in prismatic crystals, grouped so as to form hexagonal prisms. Other similar instances might be added; but this will suffice to establish the fact, that secondary planes often arise from the peculiar nature of the solvent.

In addition to this cause, may be added the electrical state of the rock supporting the crystal, and also its nature. M. Planiava has observed that, in some instances, in which the form of the *floating* crystal was the primary, it assumed secondary planes as soon as it attached itself to the sides of the vessel.* From the nature of crystallogenic attraction, it must be influenced by the electrical excitement of surrounding bodies, and in some circumstances, it may be affected by the electrical state of the atmosphere.

In some instances, secondary planes proceed from some permanent peculiarity in the molecule; for, without this supposition, we cannot account for the invariableness in the occurrence of a particular secondary form of some minerals; for example, the prismatic form in quartz, whose primary is a rhombohedron. From some preceding remarks, the reader may have already deduced, that a certain degree of force of attraction is connected with axes of a certain and definite length, and that secondary planes result from a variation of this relation. With respect, then, to the molecules of quartz, we may conjecture that they are permanently modified in this or some similar manner.

Very important discoveries would, beyond doubt, fully repay for an extensive series of experiments on this, as yet obscure, subject. From the splendid results of Mr. Crosse, who has been enabled, by the application of a weak galvanic power, to obtain crystals of several minerals, the crystallization of which had hitherto defied the powers of art, we may be encouraged to hope that ere long this entrance to one of the innermost recesses of the works of nature will be thrown open, and that the qualities of atoms, or molecules, their forms and peculiarities, will soon be fully understood. Its connection with the science of chemistry, and other physical sciences, render it deserving of very minute experimental research. Beautifully and truly was it long since remarked by Gulielmini—an author who, though afterwards forgotten, had a clearer insight into the nature of crystallization, than any of his cotemporaries, and many of his successors,—in his work, *on Crystallization*. p. 144. "Crystallisatio geometrizantis naturæ opus quoddam est, et sane mirabilissimum; dignum ideo ut totis ingenii viribus totâque mentis contentione exquiratur, non quod spectet tantam amœnita-

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* Kastner's Archiv. X. 42; cited in Ferussac's Bulletin.

tem et voluptatem, quæ mirabilium scientiam consequitur, verum etiam ob maximam in re physicâ utilitatem; videtur quippe Natura hic se prodere, et omni exutâ velamine non qualis esse potest, sed qualis actu est sese præbere conspiciendam."[*]

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[*] "Crystallization is a peculiar and most admirable result of Nature's geometry, worthy of being studied with all the power of genius, and the whole energy of the mind, not on account of the delight which always attends the knowledge of wonders, but because of its vast importance in revealing to us the secrets of Nature; for here she does, as it were, betray herself, and laying aside all disguises, permits us to behold her, not merely as she is in appearance, but as she is in true reality."

PART II.

PHYSICAL PROPERTIES OF MINERALS.

CHAPTER I.

CHARACTERS DEPENDING ON LIGHT.

89. LIGHT may be either reflected, transmitted, or emitted. The characters of minerals thus produced are of five kinds:—

1. LUSTRE; depending on the *power* and *manner* of *reflecting* light.
2. COLOR; depending on the *kind* of light *reflected* or *transmitted*.
3. DIAPHANEITY; depending on the *power* of *transmitting* light.
4. REFRACTION; depending on the *manner* of *transmitting* light.
5. PHOSPHORESCENCE; depending on the *power* of *emitting* light.

LUSTRE.

90. The lustre of minerals arises from the nature of their surfaces, which causes more or less of the light incident upon them, to be reflected. A variation in the *quantity* of light reflected, produces different degrees of *intensity of lustre;* a variation in the *nature* of the reflecting surface, produces different *kinds of lustre*.

a. The *kinds of lustre* are six, and are named from some familiar object or class of objects, which exhibit them.

1. *Metallic:* the usual lustre of metals. Imperfect metallic lustre is expressed by the term sub-metallic.

2. *Vitreous:* the lustre of broken glass. An imperfectly vitreous lustre is termed sub-vitreous. The vitreous and sub-vitreous lustres are of the most common occurrence in the mineral kingdom. Quartz possesses the former in an eminent degree; calcareous spar often the latter. This lustre may be exhibited by minerals of any color, and in any instance, should resemble broken glass of the color of the mineral.

3. *Resinous:* lustre of the yellow resins, as benzoin. Ex. opal, and some yellow varieties of zinc blende.

4. *Pearly:* this term explains itself. Ex. talc, native magnesia, stilbite, &c. When sub-metallic, the term metallic-pearly is applied.

5. *Silky:* the result of a fibrous structure. Ex. fibrous carbonate of lime, fibrous gypsum, and many fibrous minerals, more especially, those which in other forms have a pearly lustre.

6. *Adamantine:* the lustre of the diamond. When sub-metallic, it is termed metallic-adamantine. Ex. some varieties of carbonate of lead, and dark red silver ore.

b. The *degrees of intensity* are denominated as follows:—

1. *Splendent:* when the surface reflects light with great brilliancy, and gives well defined images. Ex. Elba iron ore, tin ore, some specimens of quartz and pyrites.

2. *Shining:* when an image is produced, but not a well defined image. Ex. calcareous spar, celestine.

3. *Glistening:* when there is a general reflection from the surface, but no image. Ex. talc, copper pyrites.

4. *Glimmering:* when the reflection is very imperfect, and apparently from points scattered over the surface. Ex. flint, chalcedony.

A mineral is said to be *dull* when there is a total absence of lustre. Ex. chalk, the ochres, kaolin.

These different degrees and kinds of lustre, are often exhibited differently by unlike faces of the same crystal, but always similarly by like faces. The lateral faces of a right square prism may thus differ from a terminal, and in the right rectangular prism the lateral faces also may differ. This is an immediate consequence of the fact, that these unlike faces are produced by unlike crystallogenic axes.

COLOR.

91. In descriptions of the mineral species, it is usual to notice both the external color, and that which the mineral presents when abraded with a file. The latter is by far the most important character in distinguishing minerals, for it seldom varies in the same species, though externally, the mineral may present a large variety of shades of color. The mineral species are liable to so many accidental mixtures of foreign substances, that, in general, little reliance can be placed on the external color. The metals and the metallic oxyds are among those species, which are the least subject to variation.

The color obtained by abrasion, which usually corresponds with that of the powder, is included under the term *streak.* This term includes also, the *lustre* produced by abrasion.

The following eight colors have been selected by Werner as fundamental, to facilitate the employment of this character in the description of minerals; *White, Gray, Black, Blue, Green, Yellow, Red,* and *Brown.*

The colors of minerals possessing a metallic lustre, or, concisely, THE METALLIC COLORS, are,

1. *Copper-red:* the color of copper. Copper, less perfectly, copper nickel.
2. *Bronze-yellow:* the color of bronze. Magnetic pyrites.
3. *Brass-yellow:* copper pyrites.
4. *Gold-yellow:* native gold.
5. *Silver-white:* native silver, less distinct in arsenical pyrites.
6. *Tin-white:* mercury, tin-white cobalt.
7. *Lead-gray:* galena, molybdena.
8. *Steel-gray:* nearly the color of fine grained steel on a recent fracture. Native platina, and palladium.

b. Non-metallic Colors.

The several non-metallic varieties of these fundamental colors are contained and explained in the following catalogue.

A. *White.*

1. *Snow-white:* the purest white color. Carrara marble.
2. *Reddish-white:* white, inclining to red. Some varieties of calcareous spar and quartz, &c.
3. *Yellowish-white:* white, inclining to yellow. Some varieties of calcareous spar and quartz.
4. *Grayish-white:* white, inclining to gray. The same examples.
5. *Greenish-white:* talc.
6. *Milk-white:* white, slightly bluish. Some varieties of Chalcedony.

B. *Gray.*

1. *Bluish-gray:* gray, inclining to a dirty blue color. Some varieties of limestone.
2. *Pearl-gray:* gray, mixed with red and blue. Horn silver, Pinite.
3. *Smoke-gray:* gray, with some brown. Flint.
4. *Greenish-gray:* gray, with some green. Cat's eye, some varieties of talc.
5. *Yellowish-gray:* some varieties of compact limestone.
6. *Ash-gray:* the purest gray color. Zoisite variety of epidote.

C. *Black.*

1. *Grayish-black:* black, mixed with gray, (without any green, brown, or blue tints.) Basalt, Lydian stone.
2. *Velvet-black:* pure black. Obsidian, black turmaline.
3. *Greenish-black:* pyroxene.
4. *Brownish-black:* bituminous coal.
5. *Bluish-black:* black cobalt.

D. *Blue.*

1. *Blackish-blue:* dark varieties of blue malachite.
2. *Azure-blue:* bright blue with a little red. Pale varieties of blue malachite, bright varieties of lapis-lazuli.

3. *Violet-blue:* blue mixed with red. Amethyst, fluor spar.

4. *Lavender-blue:* blue with some red and much gray. Lithomarge.

5. *Prussian-blue,* or Berlin blue: pure blue. Sapphire, kyanite.

6. *Smalt-blue:* some varieties of gypsum.

7. *Indigo-blue:* blue with black and green. Blue turmaline.

8. *Duck-blue:* blue with much green and a little black. Ceylanite variety of corundum, some varieties of talc.

9. *Sky-blue:* pale blue with a little green. It is called mountain blue by painters; it is the color of the clear sky.

E. *Green.*

1. *Verdigris-green:* green inclining to blue. Some varieties of feldspar.

2. *Celandine-green:* green with blue and gray. Some varieties of talc and beryl. It is the color of the leaves of the celandine, (Chelidonium majus.)

3. *Mountain-green:* green with much blue. Beryl.

4. *Leek-green:* green with some brown. The color of the leaves of garlic; distinctly seen in prase, a variety of quartz.

5. *Emerald-green:* pure deep green. Emerald, imperfect in green malachite.

6. *Apple-green:* light green with some yellow. Chrysoprase variety of quartz.

7. *Grass-green:* green with more yellow. Green diallage.

8. *Pistachio-green:* green with yellow and some brown. Epidote.

9. *Asparagus-green:* pale green with much yellow. Asparagus stone.

10. *Blackish-green:* some varieties of serpentine.

11. *Olive-green:* pale green, with much brown and yellow. Olivine.

12. *Oil-green:* lighter green with more yellow and less brown. The color of olive oil. Beryl, pitchstone.

13. *Siskin-green:* light green, much inclining to yellow. Uranite.

F. *Yellow.*

1. *Sulphur-yellow:* native sulphur.

2. *Straw-yellow:* very pale yellow. Some varieties of topaz.

3. *Wax-yellow:* yellow with gray and some brown. Zinc blende, opal.

4. *Honey-yellow:* yellow, with some red and brown. Calcareous spar.

5. *Lemon-yellow:* pure yellow. Native sulphur, orpiment.

6. *Ochre-yellow:* yellow with brown. Ochre varieties of brown iron ore.

7. *Wine-yellow:* pale yellow, with some red and gray. Topaz and fluor.

8. *Cream-yellow:* pale yellow, with some red and a tinge of brown. Some varieties of lithomarge.

9. *Orange-yellow:* yellow inclining to red. Orpiment.

G. *Red.*

1. *Aurora-red:* red with much yellow. Some varieties of realgar.

2. *Hyacinth-red:* red with yellow and some brown. Hyacinth variety of zircon, garnet.

3. *Brick-red:* polyhalite, some varieties of jasper.

4. *Scarlet-red:* bright red with a tinge of yellow. Cinnabar.

5. *Blood-red:* red with some yellow and black. Pyrope variety of garnet.

6. *Flesh-red:* pale red with gray and some yellow. Barytes.

7. *Carmine-red:* pure red. Ruby sapphire.

8. *Cochineal-red:* red with some blue and gray. Light red silver ore.

9. *Rose-red:* pale red with some gray. Rose quartz.

10. *Crimson-red:* red with some blue. Ruby.

11. *Peach-blossom-red:* red with white and gray. Lepidolite variety of mica.

12. *Columbine-red:* red with some blue and much black. Garnet.

13. *Cherry-red:* dark red, with much blue and brown. Spinel, some varieties of jasper.

14. *Brownish-red:* jasper, brown iron ore.

H. *Brown.*

1. *Reddish-brown:* garnet, zircon.

2. *Clove-brown:* brown with red and some blue. Axinite.

3. *Hair-brown:* brown, with some yellow and gray. Wood opal.

4. *Broccoli-brown:* brown, with blue, red, and gray. Zircon.

5. *Chestnut-brown:* pure brown.

6. *Yellowish-brown:* common jasper.

7. *Pinchbeck-brown:* yellowish-brown, with a metallic or metallic-pearly lustre. Several varieties of talc.

8. *Wood-brown:* brown with yellow and gray; color of old wood nearly rotten. Some specimens of asbestiform hornblende.

9. *Liver-brown:* brown, with some gray and some green. Jasper.

10. *Blackish-brown:* bituminous coal var. brown coal.

c. *Peculiarities in the Arrangement of Colors.*

Play of Colors. This beautiful exhibition is observed, when several prismatic colors appear in rapid succession on turning the mineral. It exists in perfection in the diamond; and also in precious opal, and is most brilliantly observed by candle light.

Change of Colors. Each particular color appears to pervade a larger space than in the play of colors, and consequently the succession produced by turning the mineral is less rapid. Ex. Labrador feldspar.

Opalescence. A reflection of a milk-white light from the interior of the specimen. It is observed in some varieties of opal, and in cat's eye.

Iridescence. An appearance of fixed prismatic colors in the interior of a crystal. It is the effect of fracture.

Tarnish. A metallic surface is tarnished, when its color differs from that obtained by fracture.

A surface possesses the *steel* tarnish, when it presents the superficial blue color of tempered steel. Ex. Columbite.

The tarnish is described as *irised,* when it exhibits the fixed prismatic colors. Ex. specular iron ore from Elba. Variegated copper ore is an instance of common tarnish.

Dichroism. Some crystals viewed by transmitted light, present different colors in different directions. This property is termed *dichroism*, derived from a Greek compound, signifying *two colors.* This property is exhibited only by crystals which have at least two unlike axes, and the different colors are observed in the direction of the different axes. It exists in turmaline, iolite, mica, &c. Mica is nearly opaque in one direction, while it is transparent in another; it also presents different colors in these directions.

DIAPHANEITY.

92. The Diaphaneity* of a mineral, is its capability of transmitting the rays of light. The following terms are adopted to express the different degrees of this property.

Transparent: when the outline of an object, behind the mineral, is perfectly distinct. Gypsum, quartz.

Subtransparent: when the object is seen, but its outline is not distinct.

Translucent: when the object is not visible, but light is transmitted. Carrara marble.

Subtranslucent: when the edges merely transmit light, or are translucent.

When no light is transmitted, the mineral is said to be *opaque.*

This property occurs in every shade of degree in the mineral kingdom, from a perfect opacity to a perfect transparency, and most minerals present, in their numerous varieties, nearly all the different shades. Few minerals, except the metals, are perfectly opaque.

REFRACTION.

93. A full treatise on the subject of *refraction of light*, belongs

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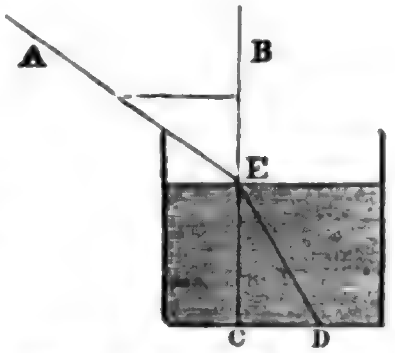
* This term has usually a less extended signification than is here applied to it. Our language is, however, destitute of any general term expressive of the capability of a body to transmit light, and therefore this, which is not in very common use, and may therefore receive a technical meaning in this science, has been here employed.

more especially to a work on optics. The remarks in this place will, therefore, be brief.

a. Simple refraction. If we look into a cup so obliquely, that an object at its bottom is concealed from view by its sides, on filling the cup with water, this object becomes visible.



This has been effected by a bending or *refracting* of the rays of light, by the water. This effect is termed *refraction*, and is produced by all transparent bodies, whether solid, liquid or gaseous.

The ray ED, within the water, is nearer the perpendicular BC, than if it had proceeded in its original direction AE. If we consider the ray as passing from the water into the air, the part, AE, is farther from the same perpendicular than if it had proceeded in the original direction DE. We have therefore this important principle: ***Light, in passing from a rarer to a denser medium, is refracted* TOWARDS *the perpendicular; if from a denser to a rarer, it is refracted* FROM *a perpendicular.***

It has been proved by experiment, that at whatever angle we look at the surface of the water, there will be a constant ratio between AB and CD, provided the eye and the object are at the same distance, A and D from E. That is, if AB is twice the length of CD, viewing it at one angle, it will be twice at every other angle, until the eye is perpendicular over the object D, when there is no refraction. But AB is the *sine* of the angle AEB, which is the *angle of incidence*, CD, the sine of the angle CED, which is the *angle of refraction*. This principle may therefore be thus stated:

The sine of the angle of incidence bears a constant ratio to the sine of the angle of refraction.

This ratio is termed the index of refraction. In water, the ratio is as 1.336 to 1. 1.336 is therefore the index of refraction of water.

b. Double refraction. A line viewed through a crystal of transparent calcareous spar, (often called Iceland spar, as it was first obtained on that island,) appears to be double. One image is observed by the usual refraction of the light, while the second is perceived by means of an *extraordinary* refraction. If the crystal is placed over a point, and turned around, one image, *that* produced by the extraordinary refraction, will appear to revolve around the other.

This power of producing double images is termed *double refraction*. It may be observed in every direction through a crystal of Iceland spar, except in that of the vertical axis. The vertical axis of the crystal is therefore termed the *axis of double refraction*, since, in its direction, the ordinary and extraordinary ray coincide.

Double refraction increases from this axis, where it is 0, to a plane at right angles with it.

In some instances, the extraordinary ray is situated between the ordinary ray and the perpendicular; in others, it is exterior to this ray. The former, possess a *greater index of refraction* for the extraordinary than for the ordinary ray, and the axis is called a *positive axis of double refraction.* The latter have a *less index of refraction* for the extraordinary than ordinary ray, and therefore a *negative axis of double refraction.*

All crystals possess the doubly refracting structure, excepting monometric solids, that is, the cube, octahedron, &c., &c. Some crystals, unlike calcareous spar, contain *two axes* of double refraction, or two directions in which the ordinary and extraordinary rays are coincident, and where, therefore, double refraction is not seen.

We remark, preliminary to an explanation of this distinction of crystals, into those with one axis, and those with two, that the molecule of a right rectangular prism has three principal sections; one through the vertical axis and the longer horizontal, another through the vertical and shorter horizontal, and a third through the two horizontal axes. These three planes of section intersect at right angles, and are called the *axial planes* of the ellipsoid, two of which are vertical, and one horizontal. With this explanation, we proceed.

If the molecule is an *ellipsoid of revolution,* in which the two vertical axial planes are *equal ellipses,* there is but *one* axis of double refraction.

If the molecule is an *ellipsoid, not* of revolution, in which the two vertical axial planes are *unequal ellipses,* there are two axes of double refraction.

The crystals of one axis, are included in the classes Dimetrica and Tetraxona; those of two axes, in the classes Trimetrica, Monoclinata, Diclinata, and Triclinata.

There are a few exceptions to this remark. The most prominent is the crystal of water, which, though secondary to a right rhombic prism, possesses but one axis of double refraction. But observing that some rhombohedrons possess positive, some negative axes, and that, consequently, double refraction is not dependent on form merely, but probably, also, on the nature of the attraction in the molecular axes, and also the structure of the molecule, we must allow the possibility of this exception, and not so violate all principles of Crystallography as to attempt to derive its forms from any *dimetric* or *tetraxonal* solid.

PHOSPHORESCENCE.

94. Phosphoresence, or the emission of light by minerals, may be produced in different ways: by friction, by heat, or by exposure to the light of the sun.

By friction. Light is readily evolved from quartz, by the friction of one piece against another, and merely the rapid motion of a feather across some specimens of sulphuret of zinc, will often elicit from this mineral, light, more or less intense. Friction, however, will evolve light from a few only of the mineral species.

By heat. Fluor spar is very beautifully phosphorescent at the temperature of about 300° F. Different varieties give off light of different colors; the *chlorophane* variety, a splendid emerald green light; others a purple of different shades. This may be observed in a dark place, by throwing the pulverized mineral on a shovel heated below redness. Some varieties of carbonate of lime emit a yellow light when treated in the same manner. At a certain temperature, the fluor spar loses the power of phosphorescence; it may be restored, however, by subjecting it to an electrical discharge.

Light of the sun. The only substance in which an exposure to the light of the sun produces very apparent phosphorescence, is the diamond—some specimens seem to be destitute of this power.

The phosphorescence of minerals is a character of little importance in distinguishing them: it is, however, deserving of attention in the descriptive part of the science.

CHAPTER II.

ELECTRICITY.

95. THE means of developing electricity in minerals, are friction and heat.

1. *By friction.* There is no line of distinction among the mineral species, separating them into those of *resinous* and those of *vitreous* electricity. The same mineral in its different varieties, often presents both kinds, and frequently, the two are exhibited by the same specimen. This character is, therefore, of no importance nor interest to the mineralogist.

2. *By heat.* The thermo-electrical character of the mineral species, are also of little importance in distinguishing minerals; but they are so peculiar that they deserve some attention, and should not be neglected in the descriptions of the species.

The effect of the application of heat, is the development of electric polarity. This property belongs in a remarkable degree to turmaline and boracite. These minerals usually occur in hemihedral crystals, the one under the form of a three or six sided prism, (secondary to a rhombohedron,) differently terminated at its extremities, the other in that of a cube, with its opposite solid angles dissimilarly replaced. M. Becquerel remarks concerning the turmaline:[*] "At 30° C. electrical polarity was sensible; it continued unchanged, to 150°, as long as the temperature continued to rise; if stationary an instant, the polarity disappeared; but shortly manifested itself *reversed*, when the temperature commenced to decline. If but one end of the crystal was heated, the crystal was unpolarized, and when two sides were unequally heated, each acquired an electrical state independent of the other."

The most modified end of turmaline is the positive or north pole. The same is true of boracite, whose opposite poles are exhibited at the opposite angles. The powder of turmaline is also pyro-electric.

The usual method of observing the polarity of turmaline, is to place the heated crystal on a brass support, which turns on a pivot like a magnetic needle. By presenting the poles of a magnet, it will be found that the north pole of a magnet will attract one extremity of the crystal and repel the other.

The following is a list of the pyro-electric minerals, as given by the *Abbé Haüy*, with the names of those who first noticed their pyro-electric property.

Turmaline, *Lemery*.
Topaz, *Canton*.
Axinite, *Brard*.
Boracite, *Haüy*.

Mesotype.
Prehnite.
Oxyd of zinc.
Sphene.
} *Haüy*.

Brewster has added the following.

Calc spar.
Yellow beryl.
Heavy spar.
Celestine.
White lead ore.
Fluor spar, (red and blue.)
Diamond.
Orpiment.

Analcime.
Amethyst.
Quartz, (Dauphiny.)
Idocrase.
Mellite ?
Sulphur, (native.)
Garnet.
Iolite.

CHAPTER III.

MAGNETISM.

96. Iron is the sole repository of magnetism in the mineral kingdom.[†] Magnetic polarity and attraction is exhibited by only one of its various ores. This ore often possesses these characters in an eminent degree, and when arranged in the form of a horse shoe magnet will often lift very heavy weights.

Several of its ores, however, are *attractable by the magnet*, though not possessed of magnetic powers themselves. This may be observed, by presenting the ordinary steel magnet to the mineral reduced to a coarse powder. If the particles are susceptible of magnetic influence, they will adhere to the applied magnet. This character serves to distinguish a few of the mineral species, which otherwise have very close resemblances; especially, magnetic iron ore from specular iron, and magnetic pyrites from common pyrites. The native magnet is a variety of magnetic iron ore.

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[*] Brewster's Edin. Jour. X. 1829.

[†] The metals cobalt and nickel are also susceptible of magnetic attraction.

Many minerals become attractable by the magnet, only after undergoing the high heat of the blowpipe; this is the result of a partial decomposition. This fact should always be observed in the descriptions of the species.

CHAPTER IV.

SPECIFIC GRAVITY.

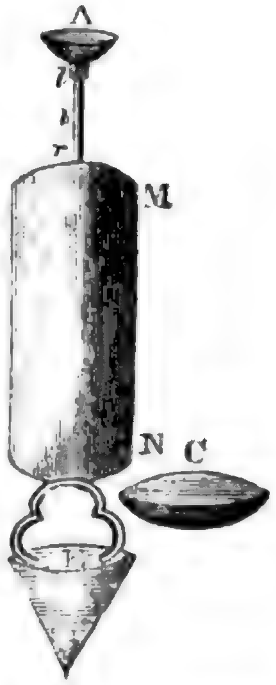
97. THE specific gravity of a mineral, is its weight compared with that of another substance of equal volume, whose gravity is taken at unity. If a cubic inch of any mineral weighs twice as much as a cubic inch of water, (water being the unit,) its specific gravity is 2, if three times as much, its specific gravity is 3, &c. In the case of solids or liquids, this comparison is usually made with water; but when the substance is a gas, atmospheric air is assumed as the unit.

It results from the nature of a fluid, that the weight lost by a solid immersed in water, is equal to the weight of an equal volume of water. The determination of specific gravity is, therefore, a very simple process. We ascertain the weight out of water by weighing it in the usual manner; we then determine the weight in water; and the loss by immersion, or the difference of the two weights, is the weight of an equal volume of water: that is, if a mineral weighs 120 grains out of water, but 90 on immersion, it has lost 30 grains, which is the weight of a volume of water equal to that of the mineral. The mineral, consequently, weighs in this instance 4 times as much as the water; for 4×30 grains, (weight of water,) equals 120 grains, which is the weight of the mineral. The rule for the process is, therefore, *Divide the weight out of water, by the difference of weights obtained out and in water.*

The water employed for this purpose should be free from all foreign substances, which may be effected by distilling it. Since the density of water varies with its temperature, a particular temperature has been selected for these experiments in order to obtain uniform results: 60° F. is the most convenient, and has been generally adopted.

If a pair of scales is used for obtaining the weights, they should be exceedingly delicate, when perfect accuracy is required. For original investigations they should turn with the 1000th of a grain. The weights must be selected with care, and should vary from the twentieth of a grain, to 120 grains. To weigh the mineral immersed in water, it may be attached to the scales by a single fibre of raw silk or a fine hair, and thus let down into a jar of water, care being taken that the scales be kept perfectly dry. The attachment of the fibre of silk to the scales, may be made by means of a small hook attached to the lower part of one scale. For the ordinary investigations of the mineralogist, in the determination of species, it will be found most convenient, if the scales are not provided with this hook, to make a very small hole through the centre of one scale, and through it attach a horse hair permanently to the scale. By tying a slipping knot in the horse hair, the minerals under investigation may be attached and detached without difficulty, owing to the elasticity of the hair; the hair thus arranged will seldom require to be replaced.

An instrument called Nicholson's Aræometer, is often substituted for the scales, and for mineral analysis is sufficiently accurate.



M N is a hollow metallic cylinder; E, a leaden support for the mineral; A a cup attached to M N by a piece of brass wire *lr;* a mark should be made at *b* on this wire, a short distance above the line to which the instrument sinks when immersed in water.

In using the instrument it is inserted into a tall glass jar containing water, and the cup C placed on A to receive the weights. The weights are now added until the instrument sinks to the line at *b*. This weight, which is to be noted and marked on the cup C, is called the *balance weight* of the instrument. It will be perceived as we proceed, that the specific gravity of no specimen of greater weight than the balance weight, can be determined with this instrument, except by changing the position of the mark *b*.

To ascertain the specific gravity of a mineral, place the specimen on C, and add such additional weights as are required to sink the instrument to *b;* subtracting this additional weight from the balance weight, gives the weight of the specimen. Next, place the specimen on the receptacle E, and having immersed the whole again in the water, add weights to C till the instrument again sinks to *b*; the weights added, equal the weight of an equal volume of water. We then divide as before the weight of the mineral by the weight of the equal volume of water.

To insure accuracy, those specimens should be selected which are perfectly free from foreign substances and contain no vacuities. If vacuities exist, they may usually be removed by a *coarse pulver-*

ization of the mineral. If reduced to an *impalpable* powder, it is apt to swim on the surface, though heavier than water, and therefore this should be avoided.

The mineralogist is so seldom required to investigate the specific gravity of liquids or gases, that an explanation of the different methods employed is unnecessary.

CHAPTER V.

CHARACTERS DEPENDING ON COHESION.

These characters are of three kinds:—1. Hardness; 2. State of Aggregation; 3. Fracture.

1. HARDNESS.

98. Every one's experience teaches him that the harder body will scratch the softer, and that therefore we may distinguish the harder from the softer by a trial of this kind. From the same instructor, the fact is universally known that the softer the substance the more easily it is impressed and abraded by a file. Both these methods are used by the mineralogist in determining the hardness of the species, but the latter is much to be preferred. Some of the objections to the former are the following:

The facility of operation depends to some considerable extent on the acuteness of the angle with which the trial of scratching is made, and it becomes very difficult if not impossible when there is no angle. 2. The result is very uncertain at low degrees of hardness. 3. It is imposssible with imbedded minerals. 4. The trial specimens must have finely polished surfaces, which are obtained with difficulty, and if polished, are soon destroyed for this purpose, after receiving a few scratches.

It might also be added, that this process is much more difficult than that by the file; and, moreover, it is unnecessary, as the file will answer in all cases. Even when the mineral is too hard to be impressed by it, the peculiarity of the grating sound will suffice to the practised ear.

To give a more definite character to the results obtained with respect to the hardness of minerals, the distinguished German mineralogist, Mohs, has introduced a *scale of hardness*. In older works on the science, the very indefinite terms *hard*, *soft*, *tender*, &c., were employed to express the degrees of hardness. Afterwards, minerals were described as harder or softer than glass, or than one another. Consequently, the standards were almost as numerous as the mineral species, and no information was conveyed to the person unacquainted with the species with which comparison was made; or if acquainted with the species, since many minerals vary somewhat in their hardness, the statement was still indefinite, unless the particular variety was noted. The confusion and incorrectness thus introduced into the science, have been removed by the selection of a few minerals of common occurrence, as standards of comparison. Mohs's scale consists of ten minerals, which gradually increase in hardness from 1 to 10. The intervals between 2 and 3, and 5 and 6, are larger than the others. Breithaupt has therefore introduced another degree of hardness between each of the above, and thus his scale is composed of twelve minerals. The advantage of Breithaupt's scale may be secured without altering the number of units of comparison, by numbering that between 2 and 3, 2½, or 2.5, and that between 5 and 6, 5½, or 5.5.

The scale, thus constructed, is as follows:

1. *Talc;* common laminated light green variety.
2. *Rock salt*, or an uncrystallized variety of gypsum.
2. 5. *Foliated mica.*
3. *Calcareous spar;* transparent variety.
4. *Fluor spar;* crystalline variety.
5. *Apatite;* transparent variety.
5. 5. *Scapolite;* crystalline variety.
6. *Feldspar;* white cleavable variety.
7. *Quartz;* transparent.
8. *Topaz;* transparent.
9. *Sapphire;* cleavable varieties.
10. *Diamond.*

If the file abrades the mineral under trial with the same ease as No. 4, and produces an equal depth of abrasion with the same force, its hardness is said to be 4. If with more facility than 4, but less than 5, the hardness may be 4¼, or 4½, written in decimals 4.25, 4.5. Several successive trials should be made to obtain certain results.

The use of the file is acquired with very little experience; usually a single trial is sufficient. Care must be taken to apply the file to similar edges in the specimens compared; that is, edges of equal obtuseness. That part, also, of the specimen should be selected, which has not been altered by exposure, and which has the highest degree of transparency and compactness of structure. The pressure for determination should not be very light, and the file should be passed three or four times over the specimen.

Some crystals present different degrees of hardness on their *unlike* parts. An example of this fact is observed in Kyanite and also in mica. This is only observed in the inequilateral primary forms, and like the similar difference of color, lustre, &c., finds a ready explanation in the theory of their formation: *unlike faces are the result of the action of unlike axes.*

2. STATE OF AGGREGATION.

99. Solid minerals may be either brittle, sectile, malleable, flexible, or elastic. Fluids are either gaseous or liquid.

1. *Brittle ;* when on detaching parts of the mineral with a knife, the separated parts fall to a powder. Ex. kerolite, calc spar.

2. *Sectile ;* when the detached parts do not fall to a powder. This character is intermediate between brittle and malleable. Ex. gypsum.

3. *Malleable ;* when the detached parts separate in slices. This is a consequence of what is usually termed malleability, or the extensibility of a substance under the hammer. Ex. native gold, native silver.

4. *Flexible ;* when the mineral may be bent without breaking, and retains its bent position when the bending force is removed. Ex. talc.

5. *Elastic ;* when on removing the bending force, the original position is reassumed. Ex. mica.

A liquid is said to be *viscous*, when, on pouring it, the drops lengthen, and appear ropy. Ex. petroleum.

3. FRACTURE.

100. The natural fracture of crystalline minerals, has already been noticed under *Cleavage*. The fracture of amorphous minerals, varies in the form and kind of surface produced.

1. *Conchoidal ;* when the minerals break with concavities, more or less deep, and corresponding elevations. It is so called from the resemblance of the concavity to the valve of a shell, from concha, *a shell*. Ex. flint.

2. *Even ;* if the fractured surface is nearly or quite flat.

3. *Uneven ;* if the broken surface is rough, with numerous small elevations and depressions.

4. *Hackley ;* when the elevations are sharp or hooked. Ex. broken iron.

CHAPTER VI.

TASTE.

101. Taste can be observed only in the soluble minerals and liquids. The different kinds of taste which have been adopted for reference are,

1. *Astringent ;* the taste of vitriol.
2. *Styptic ;* taste of alum.
3. *Saline ;* taste of common salt.

4. *Alkaline;* taste of soda.
5. *Cooling;* taste of salt petre.
6. *Bitter;* taste of Epsom salts.
7. *Sour;* taste of sulphuric acid.

This is an important character in distinguishing the soluble minerals.

CHAPTER VII.

ODOR.

102. Excepting some of the gases and soluble salts, minerals do not in the dry unchanged state give off any odor. Odor may be obtained from many, however, by friction, or by moistening their surfaces with the breath; and also by the elimination of some volatile ingredient by heat or acids. The following terms will be employed in describing the odors thus obtained from minerals.

1. *Alliaceous;* the odor of garlic. Friction of arsenical iron elicits this odor; it may also be obtained from any of the arsenical ores or salts, by means of heat.

2. *The odor of horse-radish.* This very disagreeable odor is strongly perceived, when the ores of selenium are heated.

3. *Sulphureous;* friction will produce this odor from pyrites, and heat from most of the sulphurets.

4. *Bituminous;* the odor of bitumen.

5. *Fetid;* the odor of sulphuretted hydrogen or rotten eggs. It is elicited by friction from some varieties of quartz and limestone.

6. *Argillaceous;* the odor of moistened clay. It is obtained from serpentine and some allied minerals, after moistening them with the breath; others, as pyrargillite, afford it when heated.

PART III.

CHEMICAL PROPERTIES OF MINERALS.

The chemical properties of minerals are ascertained in two ways; 1, by the action of acids; 2, by heat, concentrated by means of the blowpipe, assisted by various chemical re-agents.

CHAPTER I.

ACTION OF ACIDS.

103. When diluted sulphuric acid, (oil of vitriol,) nitric acid, (aqua fortis,) or muriatic acid, is put on a specimen of calcareous spar, or when this mineral is introduced into either of these acids, there is a rapid escape of bubbles of aërial matter, producing what is termed *effervescence.* In this instance, this aërial matter is carbonic acid, which, either of the above acids will separate from the lime. Whenever, therefore, a mineral contains a volatile ingredient capable of being expelled by an acid, this character may be employed to distinguish it from others it much resembles in its external characters. In making this trial, it is most convenient to apply the acid by means of a glass rod, directly upon the specimen. It must be closely observed, that the mineral is quite pure; any fissures or seams are very liable to contain small quantities of carbonate of lime, or some other substance equally decomposable by acids, which would, therefore, give a fallacious result. When there is any doubt as to the result obtained, it may be removed by dropping a fragment not larger than a pea, or some of the pulverized mineral, into the acid. Its reduction in size, quantity, and the accompanying effervescence, will render manifest the action of the acid. The acids, when employed for this purpose, should be at least one half water. The dilute nitric acid is generally most convenient. In some cases the others are requisite. In these examinations, it is important to observe the odor of the escaping gas; also, whether very suffocating and disagreeable, or merely pungent; also, its color, and if the experiment is performed in a vessel, the

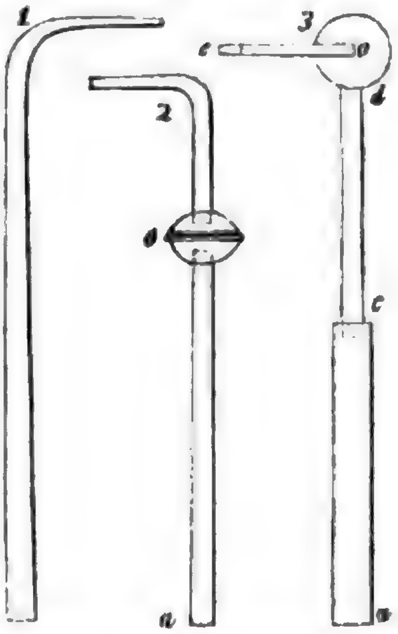
color of the solution should be observed. In many instances, solution is obtained without effervescence, and often a mineral is but partly soluble, and the insoluble part is thrown down in the state of a powder; frequently, it may be insoluble in cold, but soluble in hot acid.

Another effect of the action of acids is the reduction of the mineral to the state of a *jelly*. To accomplish this, the finely pulverized mineral is thrown into a *strong* acid, and a gentle heat applied. After a short time, as the mineral cools, it gelatinizes. In a few instances, a jelly may be formed readily with the cold acid. By heating the mineral, this property is often destroyed; but occasionally it takes place, with equal facility, before and after heating. These facts will often assist in distinguishing the mineral species, and should, therefore, be noticed in the descriptions of new species.

CHAPTER II.

ACTION OF THE BLOWPIPE.

104. The first of the annexed figures, represents the simplest kind of blowpipe. It is merely a bent, tapering tube of brass, from seven to ten inches long, with a very minute aperture at its smaller end. Its use is to concentrate the flame of the candle to a single point. This is effected by blowing with the mouth through the instrument, while its smaller end is just within the flame of the lamp or candle. For this purpose, the wick should be bent in the direction in which the flame is to be blown. With a little practice, a good focus is easily obtained.



Frequently, the operations with the blowpipe require an unintermitted heat for a considerable length of time, and always longer than a single expiration of the operator. It is, therefore, necessary, that the process of breathing and blowing should be going on cotemporaneously. This, though apparently paradoxical, may be accomplished after a little practice. The learner should first attempt to breathe through his nostrils, with his cheeks inflated and mouth closed, and be able to continue, uninterruptedly, the process of breathing without altering the inflation of the cheeks. This accomplished, if he introduces the blowpipe into his mouth, he will soon find no difficulty in continuing his respirations, while the muscles of the inflated cheeks are throwing their contained air through the blowpipe. Whenever the cheeks are nearly exhausted, the mouth may again be filled without intermitting the flame, and the respiration through the nostrils recontinued.

After blowing a short time, moisture often collects in the tube and prevents the longer continuance of the process. To remedy this inconvenience, the appendage at *o*, figs. 2 and 3, is often added to the blowpipe; it is merely a small chamber for receiving and condensing the moisture. In fig. 3, the beak is connected with the chamber by a universal joint, admitting of motion laterally, in all directions.

To avoid the necessity of putting into the mouth the brass of which the blowpipe may be made, it is usually provided with an ivory mouth-piece. It is, however, preferable that this instrument be made of silver, and quite desirable that its beak, at *e*, be of platinum. When made according to Wollaston's method, it consists of a thin tube, about seven inches long, attached at one extremity to a beak of similar form. The tube is composed of two parts, which may slide into one another, and thus the whole is made to occupy no more room than a common pencil case. The same is effected by the arrangement in fig. 2, in which the lower half, *c d*, is screwed into the upper. When unemployed, it may be unscrewed, and the part, *c d*, inserted at *a* into the part *a c*, and again screwed in. Thus arranged, it occupies no more room than according to Dr. Wollaston's plan; and on account of the greater facility of rendering it tight with a screw, this method may sometimes be preferred.

The flame produced by the blowpipe, consists of two cones; an inner of a blue color, and an outer, which is yellow. The heat is most intense just beyond the extremity of the blue flame, where the greater part of the heat of the candle is concentrated. The effect of the heat of the inner cone is to fuse, and, in many instances, to reduce the mineral (if a metal,) to its metallic state. This, therefore, is called the *reduction* flame.

The same effect is not always produced at the extremity of the outer flame. Often, the mineral reduced by the inner cone, if placed at the extremity of the outer, is recomposed, in consequence of its contact with the atmosphere, by uniting with oxygen one of the constituents of the atmosphere. For this reason, the outer flame is called the *oxydating* flame. For oxydation, the beak of the blowpipe should have a large aperture, and the wick be separated, so as to make the flame as large as possible.

The best flame is produced by means of a lamp fed by olive oil, and containing a large wick. An ordinary candle, with a large wick, will suffice for most of the purposes of the mineralogist.

105. The mineral under blowpipe examination, requires some support, which is a bad conductor of heat. The usual material employed, is well burnt charcoal. The charcoal of pine wood,

and, in general, that which is the least compact, is to be preferred. These are usually more pure carbon, and burn with less ashes. For ordinary observations, however, the more compact is the most convenient.

A reaction of the carbon may sometimes prevent the success of the operation. Platinum spoons, or forceps with platinum extremities, are then convenient substitutes. The spoons should be about three lines long, and one broad, and attached to a small handle, pointed at its extremity. When used, the handle may be inserted into a piece of charcoal, which will serve as a protection to the hand from the heat. Platinum wire may also be employed for a support; it was first introduced by Gahn. To attach the mineral, which is powdered for the purpose, first dip the extremity of the wire, moistened with the mouth, into some powdered flux, as *borax;* after melting the flux thus attached to the wire, the powdered mineral may be taken up by it in the same manner. The mineral kyanite is sometimes a convenient support, when other materials may not be at hand; also, a leaf of mica may sometimes be employed.

When it is desired to obtain the volatilized ingredient, the mineral may be supported near one extremity of a glass tube, open at both ends. The heat is then applied outside, and the volatilization goes on, and a condensation, or resolidification, at the other extremity of the tube. In this manner, the presence of water, also, may be detected.

The heat of the blowpipe is insufficient to produce any effect, on very many of the mineral species, unless some other substance is added which will assist in the fusion or reduction. These substances are called fluxes. The most common are borax, subcarbonate of soda, and salt of phosphorus or the phosphate of soda and ammonia. These, in powder, are to be mingled with the mineral, and the mixture, which should not exceed a pea in size, placed in the focus of the blowpipe.

106. The effects of the blowpipe on different minerals are very various. Some fuse at a low temperature, others with difficulty only on the thinnest edges. With many, partial volatilization follows fusion, while, with not a few, it precedes this effect, and occasionally takes place when fusion is impossible, except with the aid of fluxes. The following particulars should be attended to, in making these examinations.

1. *Previous to fusion:* the production of opacity, and a partial or entire bleaching, owing to the escape of water; this effect is readily obtained with gypsum: the separation of the laminæ, composing minerals of a foliated structure, termed exfoliation: the decrepitation, or disposition to split off, with a crackling noise: the hange of color, resulting from partial or complete decomposition: olor of the flame: carbonate of strontian tinges it red, some cop- res, green: the evolution of odorous fumes, and the odor given minerals containing sulphur, often afford a sulphureous odor,

those containing arsenic, an alliaceous odor, those containing selenium, the odor of horse-radish: the emission of light below a red heat, called phosphorescence.

2. *During and after fusion:* the change of color, and the evolution of odorous fumes, as above: the similarity, or dissimilarity, between the color of the melted and subsequently cooled globule: the frothing or intumescence, produced by the escape of aërial matter: the fluidity and general appearance of the fused globule or surface: the nature of the cooled globule, whether angular and crystalline in its form, glassy, vesicular, scoriaceous, opaque or diaphanous, free or covered with a thin incrustation, capable of affecting the magnetic needle or attractable by the magnet, metallic or unmetallic; and if metallic, whether malleable or brittle.

It should also be observed whether the support is covered with an incrustation, and the color and nature of this coating.

For a more complete account of the phenomena attending the use of this instrument, and of its effects as indicative of the composition of minerals, reference may be made to a very complete and highly valuable work on this subject, by Berzelius, which has been translated by Mr. Children.*

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* The use of the blowpipe in Chemical Analysis, and in the examination of Minerals: translated by J. G. Children. 8vo. 3 pl. London, 1822.

PART IV.

TAXONOMY.

Taxonomy is that branch of Science which investigates the principles of System. It embraces the two dependent subjects, Classification and Nomenclature.

CHAPTER I.

CLASSIFICATION.

IDENTITY, AND NON-IDENTITY OF SPECIES.

107. Abstractly considered, those individuals are conspecific that possess all the invariable qualities of a particular species. It is therefore important to understand the relative value of crystallographic, physical, and chemical characters, in the determination of identity.

a. Importance of Crystallization in Determining Identity.

The characters of minerals depending on crystallization, hold the first rank. The present elevation and perfection of the science of Mineralogy, has mostly arisen from the developments of the principles of crystallography. Indeed, the only characters in which the mineral species are invariably constant, are the form and structure of their crystals. The following canon, which was first introduced by the Abbé Haüy, is therefore fundamental in the science, and should take the precedence of all other laws or principles: *Similarity of crystallization proves an identity of species, and dissimilarity a non-identity.* When a mineral presents perfect and distinct crystals, no other character is required for its determination. By *similarity of crystallization* is understood, not merely an identity in the *system* of crystallization, but also, in analogous interfacial angles, and in cleavage. Occasionally, there is a slight variation in the angles, and in the cleavage of some of the most variable species. But they are not sufficient to affect the generality of the above canon.

But crystals are comparatively of rare occurrence. More frequently it is necessary to decide with respect to amorphous or imperfectly crystalline specimens, in which cases, we must appeal to the remaining characters, either physical or chemical.

b. Importance of the Physical Characters in Determining Identity.

The importance of these characters is quite various. They all vary more or less in some of the mineral species; but as the limits of variation, with several of these characters, are in most instances but small, by possessing a knowledge of these limits, we may often confidently determine with respect to the identity of species.

These characters should receive the attention of the mineralogist in the following order, which is a partial compromise between the importance of a character, and the facility of its determination.

1. *Lustre.* The distinction of *metallic* lustre from *non-metallic*, is of the first importance. Excepting this, *lustre* should rank low among the physical characters; for the line of demarcation between the non-metallic lustres is very indistinct, and often they are all presented by the same mineral.

2. *Streak.* The streak is a highly important character, both from its constancy, since it seldom varies with the color, and also because of the facility with which it may be determined.

3. *Hardness.* The liability of some minerals to decomposition, their accidental impurities, and the various mechanical states they may present, render this in some instances a character of some little uncertainty, It is however easily determined, and if the limits of variation are known, it may subserve an important purpose in the determination of a species. An allowance of 0.5 at least, should usually be made for variation.

4. *Specific Gravity.* This character is more constant than that of hardness, though for similar causes it is subject to some variation. Hardness has been ranked before this character on account of the superior simplicity and facility of its determination.

5. *Color.* Color is usually a very inconstant character. It is however subject to but little variation in the species which have a metallic lustre, and is therefore highly valuable in distinguishing these species. It is also not without some value in the analyses of the non-metallic minerals.

6. *Diaphaneity.* The remarks on color, also apply to the characters depending on diaphaneity.

7. *State of Aggregation.* This character is also more especially useful among the metallic minerals, but occasionally affords assistance in examinations of the non-metallic species.

8. *Taste.* Taste can be employed only among the few soluble minerals. With these it is highly important.

9. *Fracture.* This character is seldom of any value. It may be employed in distinguishing varieties rather than species.

10. *Refraction*, *Phosphorescence*, *Electricity*, *Magnetism* and *Odor*, are each of very limited importance.

c. *Importance of Chemical Characters in Determining Identity.*

When the crystallization of a species is sufficiently distinct to serve as a guide in distinguishing species, the results obtained by chemical means should never modify the decisions of the mineralogist. The differences of composition exhibited by analyses of the same species, may more frequently arise from mechanical mixtures than is generally supposed. In the process of crystallization, we should expect that those substances which might be present in the solution, would often be taken up mechanically by the crystallizing mineral, and thus afford fallacious results to the analyst. But, were it not subject to these errors, still as a test of identity of species it would be inferior to the crystallographic canon.

In the numerous instances of imperfect crystallizations, chemical and blowpipe tests are often a valuable assistance, and could not be dispensed with. They are determined with facility, and generally may be received with confidence.[*]

THEORY OF CLASSIFICATION.

108. The objects of classification are two: 1. The determination of the names of species; 2. An exhibition of the natural relations of the objects classified.

A classification for the former purpose, should be a lucid arrangement of the species according to a few prominent characters, which at the same time are the most important and the most easily determined. That, for the latter object should depend on a consideration of all natural characters, in order to bring together those species possessed of the greatest number of natural affinities. The first is termed an *artificial classification*, as the species are arranged without any reference to their natural relations, and it subserves merely the purpose of analysis. The second, on the contrary, affords a clear view of the relations of the species, and is therefore called a *natural classification.* As the first object of the student, after an introduction to the science, will be the determination of the names of species, the artificial classifications will first come under consideration.

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[*] In making this admission, that Natural-History characters are not sufficient in all instances, it does not appear that we degrade the science of Mineralogy from its rank among the Natural Sciences, as some of its most distinguished authors would affirm. The instances in which we would employ chemical characters, are those only in which the individuals have not a perfect organization. Exceptions themselves to the regular laws of nature, they necessarily introduce exceptions to the *regular* laws of science.

Theory of Artificial Classifications.

109. Were all minerals invariably crystallized, a single classification according to the different classes of crystalline forms, would be the most convenient, in all instances, for the determination of the names of species. But, unfortunately for system, irregular crystallizations are by far the most numerous. We, therefore, propose two systems of artificial classification, the one, *depending on crystallization*, the other, *independent of the same;* the former to contain only those minerals which are sometimes in the crystalline state, the latter, all the mineral species. The former will be found to be far preferable for determination, when the specimen under examination is in regular crystals.

110. The classes which readily present themselves for an artificial classification, depending on the crystalline forms, have already been given in § 24, and the means of determining the class from secondary planes in § 52. We may arrive at the class with great facility, often when the particular primary cannot be determined. A mineral of the class Trimetrica, might be ascertained to belong to this class without difficulty, while it might be impossible to distinguish, whether its primary was a right rhombic prism, right rectangular prism, right rhombic octahedron, or right rectangular octahedron. This classification is, therefore, preferable to one in which each primary, forms a separate class.

The classes in this system of Classification, are

1. Monometrica.
2. Dimetrica.
3. Trimetrica.
4. Monoclinata.
5. Triclinata.
6. Tetraxona.

It is unnecessary to repeat an enumeration of the primaries included in these classes. They have been given in § 24.

Each of these classes may be subdivided into the orders, metallic and un-metallic. The former includes minerals without metallic lustre; the latter those exhibiting this lustre. A few species have a submetallic lustre; to avoid all difficulties, these may be enumerated in each order. All the purposes of analysis may be secured, without a distribution of the species into smaller divisions, or genera.

111. In the construction of an artificial classification, *independent of crystallography*, the three classes adopted are a natural distribution of the species. They are as follow:—

1. EPIGÆA, (ἐπὶ, *upon*, and γαῖα, *earth.*)

Includes the gases, unmetallic liquids, and soluble minerals, or minerals possessing taste. These minerals have resulted from the decomposition of other species, and their formation is now going on; they are, consequently, Epigæan or superterraneous. Their specific gravity is below 3.8.

2. ENTOGÆA, (ἐντος, *within*, and γαῖα.)

Includes those insoluble minerals which occur in or compose the several rock strata, and which are, therefore, properly described as occurring *within* the earth. Sp. gr. above 1.8.

3. HYPOGÆA, (ὑπο, *beneath*, and γαῖα.)

Includes those species which were once on the surface, as a part of plants or minerals, and which have been subsequently buried; ex. the coals and resins. Sp. gr. under 1.8.

The species of the class Epigæa may be distributed into two divisions, the *first*, to include the fluid species, and the *second*, the solid. The second division may be farther subdivided, according to the taste of the species and the degree of solubility.

C. II. ENTOGÆA.	1. Lustre unmetallic.	*a*. Streak white or grayish-white.
		b. Streak colored.
	2. Lustre metallic.	

According to this table, the species of the class Entogæa are first divided into two sections; 1, those with unmetallic lustre, and 2, those with metallic lustre. Those with metallic lustre are farther subdivided according to their streak.

Those few minerals whose streak varies, or is of doubtful character, are introduced into both the divisions, in the same manner as those of doubtful or varying lustre. Thus may be avoided all difficulties arising from incorrect decisions in these doubtful cases.

The remaining class, Hypogæa, contains but few species and, therefore, requires no subdivisions.

Theory of a Natural Classification.

112. A natural classification of the mineral species should be founded on those characters that are under the cognizance of the *mineralogist*. It should afford him a distinct idea of all their external resemblances, and through these, a knowledge of their several peculiarities; for, whether engaged in studying, using, or teaching this science, his main dependence must be, and always is, their *external* characters. To these he makes his first appeal in distinguishing minerals, and on these he must place his strongest reliance, if he would impart to the student the power of discriminating between the mineral species. In the following theory of a natural classification, the external characters of the species have therefore, in general, been employed in preference to the sole use of chemical characters. The student may proceed, by its assistance, in his investigations without being impeded at every step by his ignorance of chemistry. He is not required to wade through

the difficulties of chemical science, as introductory to his mineralogical studies. The comprehension of a strictly chemical classification, requires acquaintance with the most recondite principles of that science, and cannot be fully understood without a perfect knowledge of all its general principles. The distinctions of acids and bases, not to mention others of greater difficulty, summon for their apprehension more than a superficial acquaintance with the principles of chemistry.*

With a purely chemical classification, moreover, Mineralogy is not a distinct natural science, but an appendage to the science of Chemistry.

An examination of natural objects, with respect to their characters as individuals, is the domain of Natural History. It takes cognizance of their relations as unities; it views a mineral as a simple object, and describes and considers the qualities it presents in its own capacity, and classifies by means of these qualities. It is altogether anomalous to select the character of a ***constituent element***, and make the qualities of a substance entirely distinct and wholly different from the objects to be classified, the basis of the classification.

For a deliverance from such incongruities, the science of mineralogy is indebted to one of its most distinguished cultivators, MOHS, who has exhibited in the construction of his classification, and throughout his mineralogical writings, a highly philosophical mind, and a profound acquaintance with the science of mineralogy, both physically, chemically, and crystallographically considered. His arrangement is eminently deserving of the epithet NATURAL, for, in general, it elegantly exhibits the natural relations of the mineral species, equally in the general groupings of the species into classes and orders, and in their distribution into genera.

A classification of this kind, founded on the external characters of the species, necessarily exhibits to a certain extent their chemical relations; for their chemical constitution, though not an index of their physical peculiarities, is, notwithstanding, the source whence these peculiarities proceed. Thus, while the advantages of a natural arrangement are secured, the classification possesses, as far as is profitable to the science, the qualities of a chemical arrangement, without so partaking of the niceties of chemical science as to be rather an impediment than assistance to the student.

The following is a general view of the natural classification; the relations of the orders will be more particularly explained, after this enumeration of them, with their essential characters. A few alterations have been made in the original arrangement by Mohs, where it appeared to admit of improvement.

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* For remarks on Chemical Classifications, see Appendix B.

Class I. EPIGÆA.

G. under 3·8. No bituminous odor. Taste of solid individuals, acid, alkaline, or saline.

Class II. ENTOGÆA.

G. above 1·8. Tasteless.

Class III. HYPOGÆA.

G. under 1·8.

Class I. EPIGÆA.*

Order 1. Rheutinea, (ῥευτος, *fluid.*)

Gaseous or liquid.

Order 2. Sterinea, (στερεὸς, *solid.*)

Individuals solid.

Class II. ENTOGÆA.

Order 1. Halinea, (ἅλινος, *saline.*)

H.=1—5·5. G.=1·8—3·3 Lustre unmetallic. Streak uncolored.

Order 2. Barytinea, (βαρυτης, *weight.*)

H.=2—6. G.=3—8·1. Lustre unmetallic.

Order 3. Ceratinea, (κέρας, *horn.*†)

H.=1.—2. G.=5·5—6·5. Lustre resinous, passing into adamantine.

Order 4. Osmerinea, (ὀσμηρος, *odorous.*)

H.=1·5—3. G.=2—3·1. Odor when moistened, argillaceous. Lustre unmetallic. Streak uncolored.

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* The nomenclature here adopted, which is somewhat peculiar, will be more fully exposed in a future section. The orders employed by Mohs, as translated and adopted by Haidinger and Allan, are as follow:

Class I.—Order 1. *Gas.* 2. *Water.* 3. *Acid.* 4. *Salt.*

Class II.—Order 1. *Haloide.* 2. *Baryte.* 3. *Kerate.* 4. *Terrene.** 5. *Malachite.** 6. *Mica.** 7. *Steatite.** 8. *Spar.* 9. *Gem.* 10. *Ore.* 11. *Metal.* 12. *Pyrites.* 13. *Glance.* 14. *Blende.* 15. *Sulphur.*

Class III.—Order 1. *Resin.* 2. *Coal.*

The order acid, in Class I., contains both gases, liquids, and solids, and moreover, the individuals are not uniform in presenting a sour taste. It appeared preferable to be guided by the more important natural characteristic, the mechanical state of fluidity or solidity, and consequently, instead of the four orders of Mohs in this class, I have adopted the two, Rheutinea and Sterinea.

The species of those orders in Class II., which have been omitted (those marked with an asterisk) in the classification adopted, have been distributed into those of the remaining orders, with which they appear to be closely allied. The characteristics of these orders are not apparently of sufficient importance to require the separation of the species they include from their natural congeners in the other orders. By this change, a few exceptions to the distinctions of orders and genera have been introduced. Exceptions of this kind have been found unavoidable in other branches of natural history, and are less objectionable than discrepancies in the *natural* character of the classification.

† In allusion to the horn-like lustre of the species.

Order 5. CHALICINEA, (χάλιξ, *silex.**)

H.=2—7. G.=2·6—4. Lustre unmetallic. Streak uncolored.

Order 6. HYALINEA, (ὑάλινος, *glassy.*†)

H.=5·5—10. G.=2·6—4·8. Lustre unmetallic. Streak uncolored.

Order 7. SCAPTINEA, (σκάπτος, *that which is dug.*)

H.=1—7. G.=2—8. Color dark red—black. Streak colored, unmetallic.

Order 8. METALLINEA, (μεταλλον, *metal.*)

H.=0—5. G.=5·7—20. Lustre and streak metallic. Color white, gray, yellow, or slightly reddish.

Order 9. PYRITINEA, (πυρίτης, *pyrites.*)

H.=3—6·5. G.=4·6—9·4. Lustre metallic. Streak unmetallic. Color white, yellowish or reddish. Brittle.

Order 10. GALINEA, (γελεω, *to shine.*)

H.=1—4. G.=4·2—8·5. Lustre metallic. Streak unmetallic. Color dark gray or black. Brittle.

Order 11. ADELINEA, (ἄδηλος, *unmanifest.*‡)

H.=1—4. G.=3·3—5·9. Lustre not true metallic. Streak colored.

Order 12. THEINEA, (θεῖον, *sulphur.*)

H.=1·5—2·5. G.=2—2·1. Lustre resinous. Color yellow. Streak yellowish.

CLASS III. HYPOGÆA.

Order 1. PITTINEA, (πιττα, *pitch.*)

Easily fusible.

Order 2. ANTHRACINEA, (ἀνθραξ, *coal.*)

Infusible.

The characters and names of the classes have already been explained in § 111. The greater part of the mineral species are included in the class ENTOGÆA. Unlike the EPIGÆAN species, they are insoluble, and in their superior specific gravity, their non-bituminous odor or non-carbonaceous aspect, they differ from the individuals of the class HYPOGÆA. The era of their formation was cotemporaneous with that of the rocks that contain them, whereas the Epigæan species are the result of the decomposition of other minerals, and the Hypogæan have arisen from the inhumation and consequent alteration of vegetable or animal matter.

The species of the first six orders of the class Entogæa have an *unmetallic* lustre, and, with the exception of some species in the order Barytinea, a *white* or *grayish* streak. In the remaining orders of this class, the species have a *colored* streak, and excepting the two last orders, and several species of the order Scaptinea, a *metallic* lustre.

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* The species, in general, contain silica.

† In allusion to the high degrees of lustre.

‡ The metallic nature of the species is disguised by the mineralizing ingredient.

The distinguishing characteristics of the several orders, as above given, are not in every instance sufficient to exclude all the species not contained in them. The individuals of the mineral kingdom are so very subject to accidental variations in form and appearance, that distinct lines cannot be drawn without infringing on the natural character of the arrangement. Moreover, the characters are of such a nature that they are expressed with difficulty, although to the eye they appear clearly obvious.

It may be important to consider the chemical characters of the orders in connection with their other characters. The orders Halinea and Barytinea include those species of unmetallic lustre, which are chemically salts, except the compounds of silica, boracic acid, and alumina; the latter are included in the following orders, Osmerinea, Chalicinea, and Hyalinea. Many of the former effervesce with acids, or are decomposed and give off fumes or an odor under the blowpipe, while the latter are not so affected by acids or heat. The order Halinea contains the lighter of the salts, and Barytinea the salts of the metals, together with those of barytes and strontian, which in general have high specific gravities.

The order Ceratinea includes a few metallic chlorids and iodids, which have a higher specific gravity than the species of the order Halinea, and less hardness than those of the order Barytinea.

Of the three following orders, the species of the first have an inferior hardness and lustre, and give off, when moistened by the breath, an argillaceous odor. The order Chalicinea contains, in general, minerals of less hardness than those of the order Hyalinea. There is, however, a very gradual transition in hardness from one to the other. The latter includes the species that are generally ranked as gems, with which the diamond is naturally associated.

The oxyds of the metals and the silicates, having a metallic lustre, compose the order Scaptinea. The species are dark colored, and give off no odor under the blowpipe.

The native metals are included in the order Metallinea. They invariably present a light color, (unless tarnished.) Several of them are ductile and malleable. The brittle species are wholly volatile under the blowpipe.

The orders Pyritinea, Galinea, and Adelinea, include the sulphurets, selenids, and tellurids, of the metals, which in general are brittle, and give off an odor under the blowpipe. The species of the order Pyritinea have a metallic lustre and light color; those of the order Galinea a metallic lustre and dark color; those of the order Adelinea a submetallic or unmetallic lustre. The metallic constitution of the species in the last order is disguised by the mineralizing ingredient, and from this fact is derived the name of the order.

The remaining orders require no explanations.

With regard to the distinctions or limits of genera, difficulties must be allowed so exist, far greater than in the organic kingdoms.

Yet it must be observed, that there are certain relations or affinities which may be employed, although we are destitute of the important characters arising from organization. These relations have been very happily distinguished and employed by Mohs. The striking beauties of the system will forcibly impress the minds of those who may pay it the attention it deserves. The distinctive characteristics expressed may not exhibit fully the peculiarities which separate two genera, but a slight examination of a few of the species will, in general, be sufficient to convey a distinct impression of the generic peculiarities. For example; it requires but a passing glance to observe that the genus, including the closely allied species, *feldspar*, *albite*, *Labradorite*, &c., is very evidently distinct from the following one, including *pyroxene*, *hornblende*, *epidote*, &c. The broad tabular crystallizations of the former are quite unlike the slender forms of the latter. Yet occasionally hornblende may assume a short, flattened appearance, and feldspar may lengthen itself into slender prismatic crystals. Thus, by the great variations to which the mineral species are subject, we are prevented from making sufficiently specific statements of generic characters for a clear distinction between genera. This is, however, of little importance, as the classification, from its natural character, is necessarily not adapted to the determination of the names of species, but it is rather fitted to exhibit a correct transcript of the affinities of the species, and thus to assist in imparting a particular acquaintance with their mutual relations, their resemblances, and peculiar characteristics, and also a general and systematic comprehension of the science.

For the purpose of mineralogical analysis, it is presumed that the *artificial* classifications, given in the following sections, will be found convenient and fully sufficient.

A cabinet arranged according to this system, presents a remarkable chain of affinities, running through and uniting the whole. The gases and liquids are followed by the salts, so arranged as to appear to increase in stability, hardness, and lustre, as the eye proceeds onward. Passing in review the gems, we arrive at the *diamond*, where these characters reach their climax. On the descent, we gradually pass through the metallic oxyds *without*, and then those *with*, a metallic lustre, to the native metals. From these light-colored species, we proceed to the light-colored sulphurets, and insensibly through the dark-colored sulphurets to those with a submetallic lustre, and finally arrive at the sulphurets without a metallic lustre, from which there is a natural transition to sulphur. This combustible is immediately followed by the combustibles of the class Hypogæa.

With a classification of this kind, therefore, the advantages which have been referred to are perfectly attained. The species which are closely related in their general appearance are brought in close connection, and therefore their similarities are strongly impressed on the mind: consequently the student's attention is necessarily directed from an observation of the many resemblances to a particular examination of the several peculiarities.

CHAPTER II.

NOMENCLATURE.

113. A system of nomenclature is a method of naming a class of objects, according to certain established or assumed principles. Of such a system the science of mineralogy, as generally received, is destitute. The names in use, except those by Mohs, are arbitrary, and consequently possess no advantages, except merely as appellations for the species. It has usually been sufficient to add the termination *ite* or *lite*, (originally from λίθος, *a stone*,) to the name of some person or locality, and rarely to some quality of the mineral, and thus to denote the species. Occasionally German words have been thus transformed, and introduced into our English treatises on mineralogy; and words of various languages have been forced into unnatural union. At present, therefore, mineralogical nomenclature is devoid of all system, and is destitute of those advantages that so peculiarly characterize the botanical and zoological nomenclatures. Linnæus and Werner attempted a renovation of mineralogical nomenclature, in conformity with the systems in the other branches of science. But owing to the unadvanced state of the science, their proposed nomenclatures, though adopted for a time, soon proved inadequate. A system by Mohs, the distinguished author of the natural classification which has been adopted, has been for some time before the world. Translated from the German language, in which it was published by its author, into our own less pliant language, it loses many of its advantages, and is very much wanting in conciseness and elegance of expression.

The only language fitted for a system of nomenclature, both as regards conciseness and pliability, is the Latin language. In proposing, therefore, a system of nomenclature, this language has been employed. For the acquirement of scientific information, and a systematic idea of the science, a nomenclature similar to that which will be employed, is highly important. The shorter trivial names, however, may frequently be convenient when the mineral is in common use in the arts.*

114. *Names of genera and species.* A *genus* being a family,

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* On account of the very general use of the present nomenclature of this science, the systematic names which will be proposed, will be merely appended, in the descriptive part of this treatise, to the common name.

including one or more *species*, the name of the genus should be a substantive, and that of the species an adjective, or sometimes a substantive, prefixed to, and qualifying, the generic name. The specific name should express some quality or important fact relative to the species, so that the combined name shall bring before the mind some idea of the species represented. For example; if we would name a family, composed of species having a foliated structure, we first select a substantive, conveying some general idea respecting the species, as the word *Phyllinius*, in this instance, derived from φυλλον, *a leaf*. In naming the species *hypersthene*, which belongs to this genus, an obvious quality is its submetallic lustre; this affords the combined name *Phyllinius metallinus*. In a similar manner, the systematic denomination of other species may be formed. The chemical, physical, or crystallographic characters, may, each of them, afford the names of species. Only those physical qualities should be selected which are constantly presented by the species in all, or, at least, the greater part of its varieties. The primary form of the species has been designated in the specific name by the following terms:

Cubicus,	primary form,	the cube.
Octahedrus,	" "	the regular octahedron.
Pyramidalis,	" "	octahedron not regular.
Dodecahedrus,	" "	the dodecahedron.
Quadratus,	" "	a right square prism.
Rectangulus,	" "	a right rectangular prism.
Rhombicus,	" "	a right rhombic prism.
Rhomboideus,	" "	a right rhomboidal prism.
Obliquus,	" "	an oblique prism, (restricted to the oblique rhombic.)
Triclinatus,	" "	the oblique rhomboidal prism.
Rhombohedrus,	" "	rhombohedron.
Hexagonus,	" "	hexagonal prism.

The terms *monometricus*, *dimetricus*, &c., expressing the crystallographic class of the primary, may also be employed. The term *monoclinatus*, when used, refers to the *oblique rhombic prism;* the other prism in this class, the *right rhomboidal*, will be specified as stated above. The term *prismaticus* may be applied to any prismatic crystal; it has been restricted, however, to the forms in Mohs's Prismatic system of crystallization, the Trimetric class in the system adopted.

The several varieties of cleavage may be expressed as follows:

Peritomus, (περι, *about*, and τέμνω, *to cleave.*)	Cleavage parallel to the lateral faces.
Acrotomus, (ἄκρον, *summit*, and τέμνω.)	Cleavage parallel to the basal plane.
Diatomous, (δια, *through*, and τέμνω.)	Cleavage parallel to a diagonal plane.
Eutomus, (εὖ, *easily*, and τέμνω.)	Cleavage easily effected.
Dystomus, (δυς, *difficultly*, and τέμνω.)	Cleavage obtained with difficulty.

The remaining terms which will be employed, and their explanations, will be given in connection with the full exposition of the classification, preceding the descriptive part of this treatise.

In the selection of generic terms, significant names are to be preferred, and, if possible, they should express the family peculiarity which requires the union of the species in the genus, or some quality which they have in common. Occasionally this may be difficult or impossible, in which case a name may be assumed, which, by its frequent use as the denomination of a mineral, or other object, will carry with it a general impression of the character of the genus.

Words derived from names of persons distinguished for their mineralogical attainments, or their patronage of the science, may be properly employed to designate species. But the use of other names, though of persons eminent in the other sciences, is wholly at variance with good usage and propriety. Moreover, an attempted flattery of the politically distinguished is degrading to science, and cannot be too strongly discountenanced.[*]

We have considered the masculine gender, in general, that which has been authorized, with a few exceptions, by the Latins and Greeks, and consequently have generally employed it, excepting in the first class containing the soluble species, and in the order Metallinea, whose ancient names are principally of the neuter gender. A uniformity of termination has been adopted in the generic names in some of the orders, viz., the orders Halinea, Barytinea, Pyritinea, and Galinea, in order to exhibit, as far as possible, the more general relations of the species.

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[*] For more particular rules, on the formation of systematic names, and the correct method of writing them, we would refer to Linnæi *Philosophia Botanica;* ed. tertia aucta et emendata curâ C. L. Willdenow, 8vo. *Berolini*, 1790: also *Elementa Philosophiæ Botanicæ*, auctore Henr. Frid. Link, 8vo. Berolini, 1824; and Decandolle and Sprengel's *Philosophy of Plants*, 8vo. Edinburgh, 1821.

PART V.

DETERMINATIVE MINERALOGY.

CLASSIFICATION I., DEPENDING ON CRYSTALLIZATION.

115. SOME general remarks have already been made on the systems of artificial classification, which we propose to adopt, in order to facilitate the determination of the names of the species. In the artificial classification, dependent on the crystallization of the species, the classes are subdivided, according to the lustre of the species, into sections, *unmetallic* and *metallic*. A few species of doubtful lustre are thrown into each section to avoid the difficulties that might arise from a difference of judgment on this point. A tabular arrangement has been adopted, as one best suited for reference. The order in which the characters are employed, is that depending on their relative importance, as given in § 107. The species are first arranged in the order of their hardness. No character is determined with more facility, or is more generally available; for unlike the character of specific gravity, it matters not whether the specimen be imbedded or not, in large or small masses, the hardness is arrived at with equal facility, in every variety of form of which the undecomposed species may occur.

The characters of the following columns are stated at the head of each. The number of characters employed in this classification is less than in the following system, independent of crystallization, since a less number of characters is requisite when the mineral is in perfect crystals. In the second artificial classification every character has been introduced, which could afford the least assistance in attaining the end for which it was constructed. For the convenience of reference to the full descriptions of the species, the number of the section in which the description may be found, follows the name of the species.[*]

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[*] An explanation of the abbreviations employed in the following pages, and of the manner of using the arrangement for mineralogical analysis, will be given at the close of the two artificial classifications.

CLASS MONOMETRICA.

SECTION I. LUSTRE UNMETALLIC.

Names of Species.	*Hardness.*	*Sp. Gravity.*	*Cleavage.*
Horn Silver, 273. *Prim.*	1—1·5	5·5—5·6	None; cube.
•Arsenous Acid, 133.	1·5	3·6—3·7	
•Sal Ammoniac, 149. *Volc. &c.*	1·5—2	1·528	Octahedral.
Common Salt, 142.	2	2·257	Cubic.
Native Alum, 135.	2—2·5	1·7—1·8	Oct.
Cube Ore, 217.	2—3	2·257	Imp. cub.
Blende, 530.	3·5—4	4—4·2	Dodec. perf.
Red Copper Ore, 418.	"	5·6—6·1	Oct. imp.
•Bismuth Blende, 206. *Prim.*	3·5—4·5	5·9—6·1	Dodec.
Fluor Spar, 168.	4	3—3·3	Oct. perf.
•Pyrochlore, 419. *Prim.*	5	4·2—4·3	None.
Analcime, 320. *Amyg. Volc.*	5—5·5	2—2·3	Imp.
Chromic Iron, 447. *Serpentine.*	5·5	4·3—4·5	Oct. imp.
Sodalite, 321. *Volc. &c.*	5·5—6	2·25—2·4	Dodec. imp.
Leucite, 322. *Volc.*	"	2·45—2·5	Cub. ind.
Helvin, 404. *Prim.*	6—6·5	3·1—3·3	Oct. in traces.
Garnet, 408. *Prim. Volc.*	6·5—7·5	3·5—4·3	Dodec. imp.
•Boracite, 402. *Gypsum.*	7	2·974	Oct. ind.
Automolite, 385. *Prim.*	7·5—8	4·2—4·4	Oct. perf.
Dysluite, 386. *Prim.*	"	3·5—3·6	Oct. imp.
Spinel, 384. *Prim.*	8	3·5—3·6	Oct. ind.
Diamond, 389.	10		Oct. perf.

SECTION II. LUSTRE METALLIC.

•Vitreous Silver, 505. *Prim.*	2—2·5	7·15—7·4	Dodec. imp.
Native Bismuth, 469. *Prim.*	"	9·7—9·8	Oct. perf!
•Native Amalgam, 467. *Ores merc.*	2—3·5	10·5—14	Dodec. imp.
Variegated Copper Ore, 493.	2·5—3	5—5·1	Oct. imp.
Galena, 518.	"	7·5—7·7	Cub. em.
Native Copper, 471.	"	8·4—8·8	None.
Native Silver, 465.	"	10·3—10·5	None.
Native Gold, 463.	"	12—20	None.
Gray Copper Ore, 497.	2·75—4	4·7—5·2	Ind.
•Manganblende, 529.	3·5—4	3·9—4·1	Cub. perf.
Blende, 530.	"	4—4·2	Dodec. perf.
•Tennantite, 499.	"	4·3—4·5	Dodec. imp.
•Tin Pyrites, 496. *Prim.*	4	4·3—4·4	
Platinum, 459.	4—4·5	16—19	Cubic, ind.
Iron, 458.	4·5	7·3—7·0	Oct.
•Nickel Stibine, 477.	5·5	6·4—6·5	Cub. imp.
Chromic Iron, 447. *Serpentine.*	5—5·5	4·3—4·5	Oct. imp.
Nickel Glance, 481.	"	6·05—6·2	Cub. em.
Cobaltine, 485. *Prim.*	"	6·1—6·3	Cub. perf.
•Cobalt Pyrites, 487. *Prim.*	"	6·3—6·4	Cub. imp.
Smaltine, 484.	"	6·4—6·5	Oct. imp.
Franklinite, 454. *Prim.*	5·5—6·5	4·8—5·1	Oct. imp.
Magnetic Iron Ore, 453.	"	5—5·1	Oct. imp.
Iron Pyrites, 491.	6—6·5	4·8—5·1	Cub. imp.

CLASS MONOMETRICA.

SECTION I. LUSTRE UNMETALLIC.

Lustre.	*Color, Diaphaneity, &c.*
Res . . ad.	C. gy ; bh, gnh, bnh : St. sh : Trl—sbtrl : Malleable and sectile.
Vit—Silky.	C. w ; ywh, rdh : St. w : Trp—op : T. astringent, sweetish : Sectile.
Vit.	C. w ; ywh, gyh : Trl—op : T. pungent and saline.
Vit.	T. purely saline.
Vit.	C. w : Trl : T. sweetish astringent and acid ; like common alum.
Subad.	C. gn ; ywh, bkh ; bn : St. pale olive gn—bn : Trl—op.
Ad.—res.	C. bn, bk, yw, rd, gn : St. w—rdh-bn : Trp—op.
Ad.	C. cochineal and carmine rd : St. bnh-rd : Sbtrp—sbtrl.
Res.	C. bn, ywh-gy, straw-yw : St. ywh-gy : Sbtrp—op.
Vit.	C. various : Trp—sbtrl. Phosphorescent when heated.
Res., vit.	C. dark rdh-bn : St. pale bn : Sbtrl—op. Octahedral.
Vit.	C. w ; gyh ; flesh-red : St. w : Trp—op. Cubic and trapezohedral.
Submet.	C. between iron-bk and bnh-bk : St. bn : Op.
Vit.	C. b, bn, gn, gy, w : St. w, or bh : Trl—op.
Vit.	C. w, gyh-w : St. w : Trl—op. Trapezohedral.
Vit. res.	C. wax-yw, ywh-bn, gn : St. w. Tetrahedral.
Vit. res.	C. rd, bn, bk, w, yw, gn : St. w, gyh-w : Trp—op.
Vit . . ad.	C. w ; gyh, ywh, gnh : St. w. Cubic, hemihedral.
Vit . . res.	C. dirty gn ; bk : St. w : Sbtrl—op.
Vit . . res.	C. ywh-bn, gyh-bn : St. paler : Sbtrl—op.
Vit.	C. rd, b, gn, yw, bn, bk : St. w : Trp—op. Octahedral.
Ad.	C. various.

SECTION II. LUSTRE METALLIC.

Met.	C. and St. bkh-lead-gy : St. sh.
Met.	C. and St. silver-w, rdh ; subject to tarnish : Sectile.
Met.	C. and St. silver-w.
Met.	C. bnh and rdh-yw ; tarnish bh, rdh : St. pale gyh-bk ; sh.
Met.	C. and St. lead-gy ; tarnish gyh-bk. Rather sectile. Frangible.
Met.	C. and St. rdh : Ductile and malleable.
Met.	C. w ; tarnish gyh-bk : Ductile.
Met.	C. gold-yw : Very ductile and malleable.
Met.	C. and St. steel-gy, iron-bk : St. sometimes bnh. Tetrahedral.
Submet.	C. iron-bk ; bn on exposure : St. gn : Rather sectile.
Submet, ad, res.	C. bn, yw, bk, rd, gn : St. w—rdh-bn : Trp—sbtrl.
Met.	C. bkh-lead-gy : St. rdh-gy. Brittle.
Met.	C. steel-gy ; ywh : St. bk : Brittle.
Met.	C. and St. steel-gy : Ductile.
Met.	C. and St. iron-gy : St. shining: Ductile : Acts on the magnetic needle.
Met.	C. steel-gy . . silver w.
Submet.	C. between iron-bk and bnh-bk : St. bn. Octahedral.
Met.	C. silver w—steel-gy.
Met.	C. silver-w . . rdh : St. gyh-bk. Hemihedral, cubic.
Met.	C. pale steel-gy ; tarnish rdh : Brittle. Cubic.
Met.	C. tin-w . . steel-gy : St. gyh-bk. Faces of cube often curved.
Met.	C. iron-bk : St. rdh-bn.
Met.	C. iron-bk : St. bk.
Met.	C. yw ; tarnish gyh-bk : St. bnh-bk. Hemihedral.

CLASS DIMETRICA.

SECTION I. LUSTRE UNMETALLIC.

Names of Species.	*Hardness.*	*Sp. Gravity.*	*Cleavage.*
•Horn Quicksilver, 274.	1—2.	6·4—6·5.	Imp.
•Uranite, 272.	2—2·5.	3·12.	P em.
Mellite, 539. *Coal.*	2—2·75.	1·5—1·7.	P dif.
Corneous Lead, 233. *Lead ore.*	2·75—3.	6—6·1.	M.
Molybdate of Lead, 242. *Lead ores*	"	6·5—6·9.	Oct. perf.
Tungstate of Lead, 244. *Lead ores*	"	7·9—8·1.	P.
•Edingtonite, 306. *Amyg.*	4—4·5.	2·7—2·8.	M perf.
Tungstate of Lime, 202. *Prim.*	"	6—6·1.	Oct. dist. A : A=100° 8′.
•Xenotime, 201.	4·25—5.	4·5—4·6.	M perf.
Apophyllite, 316. *Volc. &c.*	4·5—5.	2·2—2·4.	P em.
•Humboldtilite, 557. *Volc.*	5.	3·1—3·2.	
Hausmannite, 437.	5—5·5.	4·7—4·8.	P perf.
Scapolite, 351. *Prim.*	5—6.	2·6—2·8.	M dist. P trace.
•Œrstedite, 430. *Prim.*	5·5.	3·6—3·7.	a : a=123° 16′.
•Gehlenite, 353. *Prim. limestone.*	5·5—6.	2·9—3·1.	Ind.
•Anatase, 416. *Prim.*	"	3·8—3·9.	A & P perf. A : A=97° 56′.
•Fergusonite, 432. *Prim.*	5·5—6.	5·8—5·9.	Ind.
•Gismondine, 354. *Volc.*	"	2·1—2·2.	M imp.
Idocrase, 407. *Volc. and prim.*	6—6·5.	3·3—3·6.	M ind.
Rutile, 414. *Prim.*	"	4·1—4·3.	M.
•Braunite, 438.	"	4·8—5.	Oct. dist.
•Mellilite, 355. *Volc.*	6—7.	3—3·3.	
Tin Ore, 420. *Prim.*	6—7.	6·5—7·1.	Ind.
Zircon, 409. *Volc. prim. &c.*	7·5.	4·5—4·8.	Imp.

SECTION II. LUSTRE METALLIC.

•Foliated Tellurium, 521.	1—1·5.	7—7·2.	P perf.
Copper Pyrites, 494.	3·5—4.	4·1—4·2.	Ind.
Hausmannite, 437.	5—5·5.	4·7—4·8.	P perf.
•Braunite, 438.	6—6·5.	4·8—4·9.	Oct. dist.

CLASS TRIMETRICA.

SECTION I. LUSTRE UNMETALLIC.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Form, M : M.*	*Cleavage.*
Talc, 295. *Prim. amyg.*	1—1·5.	2·7—2·8.	Rbc. 120° nearly.	P em!
Copper Froth, 266. *Copper ores.*	"	3—3·1.	Rbc.	P em.
•Orpiment, 537.	1·5—2.	3·4—3·6.	Rbc. 100° 40′.	ĕ perf!
Sulphur, 538.	1·5—2·5.	2—2·1.	Rbc. Oct.	Ind.

CLASS DIMETRICA.

SECTION I. LUSTRE UNMETALLIC.

Lustre.	*Color, Diaphaneity, &c.*
Ad.	C. ywh-gy, ash-gy : St. w : Trl—sbtrl : Sectile.
P p'rly, M ad.	C. gn : St. paler gn : Trp—sbtrl.
Res . . vit.	C. honey-yw ; rh, bnh ; St. w : Trp—trl : Sectile.
Ad.	C. w ; gyh, ywh, gnh : St. w : Trp—trl.
Res.	C. wax-yw ; orange-yw, gyh-w, olive-gn : St. w : Sbtrp—sbtrl.
Res.	C. gn, gy, bn ; r : St. w.
Vit.	C. gyh-w : St. w : Trl.
Vit . . ad.	C. w, ywh-gy, y, rdh-bn : St. w : Sbtrp—sbtrl. Brittle.
Res.	C. ywh-bn : St. pale-bn : Op.
P p'rly, M vit.	C. w ; gyh, rdh, bh : St. w : Trp—op.
Vit.	C. y, ywh-gy : Sbtrp.
Submet.	C. bnh-bk : St. dark rdh-, or chesnut-bn : Op.
Vit . . p'rly.	C. w, gy, b, rdh ; colors light : St. gyh-w : Trp—op.
Splendent.	C. bn.
Res . . vit.	C. gy, ywh ; not bright : St. w, gyh-w.
Met. ad.	C. bn, indigo-b : St. w : Sbtrp—op.
Submet . . res.	C. dark bnh-bk : St. pale-bn : Trl. and pale in thin scales : Sbtrl—op.
Ad.	C. pale smalt-b, milk-w ; gy, rose-rd : Trp—trl.
Vit . . res.	C. bn, gn ; yw, colorless ; often bright : St. w, gyh-w : Trp—sbtrl.
Met-ad.	C. rdh-bn, r : St. pale-bn : Trl—op.
Sub-met.	C. dark bnh-bk : St. similar : Op.
Vit.	C. yw ; rdh, gnh : Op.
Ad.	C. bn, bk ; w, gy, yw, r : St. gy—pale-bn. Sbtrp—op.
Ad.	C. r, bn, yw, gn, gy, w : St. w : Trp—sbtrl.

SECTION II. LUSTRE METALLIC.

Met.	St. and C. bkh-lead-gy : Flexible in thin lam. Sectile.
Met.	C. brass-yw : St. gnh-bk ; a little shining : Op : Brittle.
Submet.	C. bnh-bk : St. rdh, chesnut-bn : Op.
Submet.	C. dark bnh-bk : St. similar : Op.

CLASS TRIMETRICA.

SECTION I. LUSTRE UNMETALLIC.

Lustre.	*Color, Diaphaneity, &c.*
Pearly.	C. light gn—w : St. w : Sbtrp—trl : Feel soapy : Lam. flex. inelastic.
P'rly, M vit.	C. apple-gn . . sky-b : St. paler : Lam. flex.
P'rly ; met.-p'ly ; res.	C. lemon-yw : St. yw : Sbtrp—sbtrl : Lam. flex., inelastic.
Res.	C. yellow : Trp—sbtrl : Sectile. Burns with a blue flame.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Form, M : M.*	*Cleavage.*
•Haidingerite, 175. *Prim.*	1·5—2·5.	2·8—2·9.	Rbc. 100°.	P perf!
Nitre, 153.	2.	1·9—2.	Rbc. 120°.	
Epsom Salt, 145.	2—2·5.	1·7—1·8.	Rbc. 99° 38′.	ĕ perf.
White Vitriol, 158.	"	2—2·1.	Rbc. 90° 42′.	ĕ perf.
•Thenardite, 144.	"	2·7—2·8.	Rbc. 125°.	P perf; M.
•Liroconite, 260. *Cop. ores.*	"	2·85—3.	Rect. Oct.	Imp.
•Cryolite, 165. *Prim.*	"	2·9—3.	Rect.	P perf; M̆ and M̄.
•Hopeite, 210.	2·5—3.	2·4—2·8.	Rbc. 101° 24′.	ĕ perf.
Picrosmine, 291. *Prim.*	"	2·55—2·7	Rect.	M̄ perf; M̆.
•White Antimony, 203. *Antimony ores.*	"	5·5—5·6.	Rbc. 136° 58′.	M. em.
•Melanochroite, 246. *Lead ores.*	"	5·7—5·8.		
Anglesite, 238. *Lead ores.*	"	6·2—6·3.	Rbc. 103° 49′.	Imp.
•Caledonite, 248. *Lead ores.*	"	6·4.	Rbc. 95°.	ĕ dist. M ind.
•Cerasite, 235. *Lead ores.*	"	7—7·1.	Rbc. 102° 27′.	M perf.
Roselite, 178.	3.		Rbc. 132° 48′.	é perf.
Heavy Spar, 193.	2·5—3·5.	4·6—4·8.	Rbc. 101° 42′.	M and P.
Celestine, 189.	2·75—3·5	3·6—4.	Rbc. 103° 58′.	M perf. P.
Olivenite, 263.	3.	4·1—4·3.	Rbc. 110° 50′.	Imp.
Anhydrite, 177.	3—3·5.	2·89.	Rect.	M̄ and M̆ perf. P dist.
•Atacamite, 264. *Volc. &c.*	"	4—4·1.	Rbc. 100°.	P perf.
White Lead, 232.	"	6·1—6·5.	Rbc. 117° 13′.	M and ĕ perf.
Witherite, 191.	3—3·75.	4·2—4·4.	Rbc. 118° 30′.	Imp.
•Mesolite, 314. *Amyg.*	3·5—4.	2·3—3·4.		Perf. in one direction.
Strontianite, 188.	"	3·6—3·8.	Rbc. 117° 32′.	M perf.
•Wavellite, 173.	3·25—4.	2·2—2·4.	Rbc. 122° 15′.	M and ĕ perf.
Stilbite, 304. *Amyg. and prim.*	3·5—4.	2·1—2·2.	Rect. *e* : *e*=93°.	M perf. M imp.
Arragonite, 181.	"	2·6—3.	Rbc. 116° 10′.	M.
•Scorodite, 219.	"	3·1—3·3.	Rbc. 119° 2′.	M and ĕ imp.
•Brochantite, 267. *Cop. ores.*	"	3·7—3·8.	Rbc. 117°.	Imp.
Libethenite, 262.	4.	3·6—3·8.	Rbc. 95° 2′.	Imp.
•Epistilbite, 312. *Amyg. volc.*	4—4·5.	2·2—2·3.	Rbc. 135° 10′.	é perf.
•Harmotome, 318. *Amyg. &c*	"	2·4—2·5.	Rect.	Imp.
•Phillipsite, 319. *Amyg. volc.*	4·5.	2—2·2.	Rect.	
•Electric Calamine, 208.	4·5—5.	3·3—3·5.	Rbc. 103° 53′.	M perf.
Thomsonite, 305. *Amyg.*	4·75.	2·25—2·4	Rect. *e* : *e*=90° 40′	M̄, ᴍ perf!
Euchroite, 258. *Prim.*	"	2·3—3·4.	Rbc. 117° 20′.	M dist.
Natrolite, 307. *Volc. amyg.*	4·5—5·5.	2·1—2·3.	Rbc. 91° 10′.	M perf.
•Childrenite, 172.	"	4·2—4·3.	Rbc. e : e=97° 50′	Imp.
•Herderite, 171. *Prim.*	5.	2·9—3·1.	Rbc. 115° 53′.	Imp.
•Triphyline, 221. *Prim.*	"	3·6.	Rbc. 132°.	P perf.
Mesotype, 308. *Amyg. volc.*	5—5·5.	2·2—2·3.	Rbc. 91° 28′.	M perf.
•Comptonite, 315. *Volc. amy*	"	2·3—2·4.	Rect.	M̆ dist. M̄ ind.
Brown Iron Ore, 451.	"	3·9—4·1.	Rbc. 130° 40′.	ĕ rather dist.
Wolfram, 436. *Prim.*	"	7·1—7·4.	Rect. *e′* : *e′*=101° 5′	M perf.
•Scolecite, 309. *Volc. amyg.*	5—6.	2·2—2·3.	Rbc. 91° 25′.	
Lazulite, 337.	"	3—3·1.	Rbc. 91° 30′.	Ind.
•Elæolite, 343. *Prim.*	5·5—6.	2·5—2·7.	Rbc. 112°.	M and P.
•Brookite, 417.	"		Rbc. 100°.	ĕ.
Yenite, 450. *Prim.*	"	3·8—4·1.	Rbc. 112° 37′.	ĕ.
Spodumene, 360. *Prim.*	6·5—7.	3·1—3·2.	Rbc. 93° nearly.	M.
Polymignite, 431. *Prim.*	"	4·7—4·9.	Rect.	Ind.
Prehnite, 332. *Amyg. prim.*	6—7.	2·8—3.	Rbc. 99° 30′.	P. dist.
•Humite, 406. *Volc.*	6·5—7.		Rbc. 120°.	ĕ.
•Chrysolite, 392. *Volc. basalt*	"	3·3—3·5.	Rect.	M and ĕ dist.
Iolite, 395. *Prim.*	7—7·5.	2·55—2·7	Rbc. 120°.	Ind.
Staurotide, 411. *Prim.*	"	3·6—3·8.	Rbc. 129° 31′.	ĕ ind.
Andalusite, 373. *Prim.*	7·5.	3·1—3·35	Rbc. 91° 33′.	M dist.
•Ostranite, 412.	7—8.	4·3—4·4.	Rbc. 96°.	ĕ ind.
•Forsterite, 391. *Vesuv.*	7·5—8.		Rbc. 128° 54′.	P perf!
Topaz, 390. *Prim.*	8.	3·4—3·6.	Rbc. 124° 19′.	P perf!
Chrysoberyl, 383. *Prim.*	8·5.	3·5—3·8.	Rect.	M̆ dist.

Lustre.	*Color, Diaphaneity, &c.*
Vit.	C. w: St. w: Trp—trl: Lam. flex.
Vit.	C. w: Taste saline and cooling. Deflagrates on burning coals.
Vit.	C. w: T. saline and bitter.
Vit.	C. w: Trp—trl: T. astringent, metallic, very nauseous.
Vit.	C. w: Trp: T. saline and bitter; wholly soluble: Efflorescent.
Vit . . res.	C. and St. light b—gn: Sbtrp—trl.
Vit . . p'rly.	C. w; rdh, bnh: St. w: Sbtrp—trl: Fusible in flame of a candle.
Vit; ĕ subp'rly.	C. gyh-w: St. w: Trp—trl.
M. p'rly; vit.	C. gnh-w, dark gn: St. w: Sbtrl—op.
Ad. and p'rly.	C. w; peach-blossom-red, ash-gy: St. w: Trp—trl.
Res. glim.	C. btwn cochineal and hyacinth-r; lemon-yw on exposure: St. brick-red: Sbtrl—op.
Ad; vit; res.	C. w, gyh, ywh, gnh, bh, ash-gy: St. w: Trp—sbtrl.
Res.	C. deep verdigris or bh-gn: St. gnh-w: Trl.
P-rly.	C. ywh-w, rdh-w: St. w: Feebly trl—op.
Vit.	C. deep rose-r: St. w: Trl.
Vit . . p'rly & res.	C. w: ywh: St. w: Trp—trl.
Vit . . p'rly & res.	C. w, sky-blue: St. w: Trp—trl.
Ad . . vit & p'rly.	C. gn, bn: St. olive-gn—bn: Sbtrp—op.
P'rly and vit.	C. w: St. gyh-w: Trp—trl.
Ad. vit.	C. some shade of gn: St. pale-gn: Sbtrp—sbtrl.
Ad. res.	C. w, gyh, bnh: St. w, gyh-w: Trp—trl: Brittle.
Vit . . res.	C. w, ywh-gy: St. w: Sbtrp—trl.
Silky or p'rly.	C. gyh-w, ywh-w: St. w: Trl: Lam. slightly elastic.
Vit.	C. light-gn, w: Trp—trl.
P'rly . . vit & res.	C. w, gn, b, yw, bn: St. w, gyh-w: Trl.
P'rly and vit.	C. w; ywh, r, bnh: St. w: Sbtrp—trl.
Vit--res.	C. w; gyh, ywh: St. gyh-w: Trp—trl.
Vit, subad, res.	C. leek-gn, liver-bn: St. w: Sbtrp—sbtrl.
	C. emerald-gn, bkh-gn: Trp.
Res.	C. dark olive-gn: St. olive-gn: Sbtrl.
ĕ p'rly, M vit.	C. and St. w: Trp—sbtrl.
Vit.	C. w; gyh, ywh, rh, bnh: St. w: Sbtrp—trl. Crystals often cruciform.
Vit.	C. w; rdh: St. w: Trl—op.
Vit, p'rly.	C. w; b, gn, y, bn: St. w: Trp—trl.
Vit . . p'rly.	C. w; bnh, rdh: St. w: Trp—trl.
Vit.	C. emerald-gn: St. pale-gn: Trp—trl.
Vit.	C. w; ywh, rdh, gyh: St. gy: Trp—trl.
Vit . . res.	C. y, pale ywh-bn, ywh-w: St. w: Trl.
Vit. . . subres.	C. ywh-w, gnh-w; St. w: Trl.
	C. gnh-gy; bh: St. gyh-w: Trl—sbtrl.
Vit.	C. w; gyh, rdh: St. w—gyh-w: Trp—trl.
Vit.	C. w; ywh, gyh, rdh: St. gy: Trp—trl.
Ad . . submet.	C. ywh-bn, bkh-bn: St. ywh-bn: Strp—op: Trp. cryst. blood-r. by [transmitted light.
Submet.	C. dark gyh-bk, bnh-bk: St. dark rdh-bn: Op.
Vit . . p'rly.	C. and St. w: Trp—trl.
Vit.	C. b: St. w: Sbtrp—op.
Res. or oily.	C. dark-gn; bh, gyh, bnh; brick-red: St. w.
Met-ad.	C. hair-bn, orange-yw: St. ywh-w: Trl—op.
Submet.	C. dark gyh-bk, nearly iron-bk: St. gnh, or bnh-bk: Op.
P'rly.	C. gyh-gn, gnh-w, gyh-w: St. w: Trl—op.
Submet, splend.	C. bk: St. dark-bn: Opaque.
Vit, P p'rly.	C. light gn—w: St. w: Sbtrp—trl: Often aggregated in glob. shapes.
Vit.	C. ywh-w, rdh-bn: Trp—trl: Brittle: Cryst. small; from Vesuvius.
Vit.	C. gn, light-bn: St. w: Trp—trl.
Vit.	C. light-b; bkh, ywh, gyh: St. w: Trp—trl.
Vit, subres.	C. rdh-bn, bn, bk: St. w: Trl—op; usually the latter.
Vit.	C. flesh-r, pearl-gy: St. w: Sbtrl—op: Tough.
Vit.	C. clove-bn; very brittle.
Vit, splend.	Colorless: St. w: Trl.
Vit.	C. pale y, gn—w: St. w: Trp—sbtrl.
Vit.	C. gn; ywh, gyh: St. w: Trp—trl.

SECTION II. LUSTRE METALLIC.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Form, M : M.*	*Cleavage.*
*Sternbergite, 522. *Silver ores.*	1—1·5.	4·1—4·3.	Rbc. 119° 30′.	P em !
*Graphic Tellurium, 509. *Gold.*	1·5—2.	5·7—5·8.	Rbc. 107° 44′.	M perf! P perf.
*Auro-Tellurite, 464.		10·6–10·7	Rbc. 105° 30′.	Ind.
*Gray Antimony, 512.	2.	4·5—4·7.	Rbc. 90° 45′.	é perf! M ind.
Pyrolusite, 442.	2—2·5.	4·8—5.	Rbc. 93° 40′.	M, ĕ, ē.
*Antimonial Sulphuret of Silver, 510.	"	5·5—5·6.		M perf.
Sulphuret of Bismuth, 525.	"	6·5—6·6.	Rect. $e : e$=91°.	$\bar{M}$ perf. P.
*Brittle Silver Ore, 509.	"	6·2—6·3.	Rbc. 115° 39′.	Imp.
*Jamesonite, 515.	"	5·5—5·8.	Rbc. 101° 20′.	P perf. M ind.
Vitreous Copper, 500.	2·5—3.	5·5—5·8.	Rbc. 119° 35′.	M ind.
*Bournonite, 498.	"	5·7—5·8.	Rect.	Imp.
*Newkirkite, 446. *Redhematite.*	3—3·5.	3·8—3·9.	Rect.	
*Zinkenite, 514. *Antimony ores.*	3·5.	5·3—5·4.	Rbc. 120° 39′.	None.
*Antimonial Silver, 474.	3·5—4.	9·4—9·8.	Rbc. 120° ?	P dist.
Manganite, 441.	4—4·5.	4·3—4·4.	Rbc. 99° 40′.	ē.
Brown Iron Ore, 451.	5—5·5.	3·9—4·1.	Rbc. 130° 40′.	ē rather dist.
Wolfram, 436. *Prim.*	"	7·1—7·4.	Rect.$e' : e'$=101°5′	M perf.
Leucopyrite, 482.	"	7·2—7·4.		
Yenite, 450.	5·5—6.	3·8—4·1.	Rbc. 112° 37′.	
Columbite, 434. *Prim.*	5—6.	5·9—8.	Rect.	Ind.
Mispickel, 483. *Prim.*	"	6·1—6·2.	Rbc. 111° 12′.	M.
White Iron Pyrites, 490.	6—6·5.	4·6—4·9.	Rbc. 107° 36′.	M.
*Polymignite, 431. *Prim.*	6·5.	4·7—4·9.	Rect.	Ind.

CLASS MONOCLINATA.

SECTION I. LUSTRE UNMETALLIC.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Form.*†	*Cleavage.*
*Red Antimony, 531. *Antimony ores.*	1—1·5.	4·5—4·6.	Rbdl. 101° 19′.	M perf.
*Cobalt Bloom, 231.	1·5—2.	2·9—3.	Rbdl. 124° 51′.	P perf!
Vivianite, 223.	"	2·6—2·7.	Rbdl. 125° 18′.	P em !
*Realgar, 536.	"	3·5—3·6.	Rbc. 74° 26′.	Imp.
Copperas, 154.	2.	1·8—1·9.	Rbc. 82° 20′.	P perf.
Gypsum, 176.	"	2·3—2·35	Rbdl. 113° 8′.	P perf. M & T imp.
*Borax, 134.	2—2·5.	1·716.	Rbc. 93° 30′.	M perf.
*Botryogen, 161.	"	2·039.	Rbc. 119° 56′.	M.
*Pharmacolite, 174.	"	2·6—2·8.	Rbdl. 96° 46′.	P em !
Common Mica, 298.	"	2·8—3.	Rbc. 120°.	P em !
Johannite, 160.	"	3·1—3·2.	Rbc. 111° ?	
*Miargyrite, 532.	"	5·2—5·4.	Rbc. 86° 4′.	M imp.
*Dyoxylite, 237. *Lead ores.*	"	6·8—7.	Rbc. 120° 45′.	ē perf.
*Gay-Lussite, 139.	2·5.	1·9—2.	Rbc. 68° 50′.	M perf; P dist.
*Leadhillite, 236. *Lead ores.*	"	6·2—6·5.	Rbc. 59° 40′.	P perf.

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† The angle given is M : M, when the primary is the oblique rhombic prism, and

SECTION II. LUSTRE METALLIC.

Lustre.	*Color, Diaphaneity, &c.*
Met.	C. dark pinchbeck-bn: St. bk: Lam. flex. like tin-foil. Sectile.
Met.	C. and St. steel-gy; very sectile.
Met.	C. silver-w—brass-yw: St. similar: Rather brittle: Opaque.
Met.	C. and St. lead-gy . . steel-gy; tarnishes: Sectile; very fusible.
Met.	C. iron-bk, bh: St. bk: Opaque: Somewhat sectile.
Met.	C. light steel-gy . . silver-w.
Met.	C. and St. lead-gy: Opaque: Sectile: Fusible in flame of candle.
Met.	C. and St. iron-bk: Sectile.
Met.	C. and St. steel-gy: Sectile.
Met.	C. and St. bkh-lead-gy; tarnish b, gn: Very sectile.
Met.	C. and St. steel-gy, bkh-gy. Brittle.
Met.	C. brilliant bk: Somewhat sectile.
Met.	C. and St. steel-gy.
Met.	C. and St. silver-w—tin-w. Not malleable.
Submet.	C. dark steel-gy, iron-bk: St. rdh-bn, bk: Brittle.
Submet, ad.	C. bkh-bn, ywh-bn: St. ywh-bn: Sbtrp—op.
Submet.	C. dark gyh-bk, bnh-bk: St. dark rdh-bn: Brittle.
Met.	C. silver-w, steel-gy: St. gyh-bk: Brittle.
Submet.	C. nearly iron-bk, dark gyh-bk: St. gnh-bk, bnh-bk: Op.
Submet.	C. gyh, bnh, bh-bk: St. bn, rdh-bn, bnh-bk: Brittle.
Met.	C. silver-w, steel-gy: St. dark-gy: Brittle.
Met.	C. pale bronze-yw; gyh, gnh: St. gnh-bk, bnh-bk: Brittle.
Submet.	C. bk: St. dark-bn. Fracture conchoidal, brilliant.

CLASS MONOCLINATA.

SECTION I. LUSTRE UNMETALLIC.

Lustre.	*Color, Diaphaneity. &c.*
Ad.	C. cherry-r: St. bnh-r: Trl—sbtrl: Sectile.
P'rly & ad—vit.	C. r; gyh: St. paler: Trp—sbtrl. Lam. flex. in one direction.
P'rly—submet.	C. b, gn; indigo-b: St. b, bn: Trp—trl. Lam. flex.
Res.	C. bright-r: St. orange-yw—aurora-r: Sectile.
Vit.	C. gn; wh: St. w: Sbtrp—trl: T. sweetish-astringent and metallic.
P'rly and vit.	C. w; gyh, ywh: St. w: Trp—trl: Tasteless: Very sectile.
Res.	C. w; gyh, gnh; ywh. on exposure: St. w: T. sweetish-alkaline, feeble.
Vit.	C. deep hyacinth-r; ochre-yw: St. ochre-yw: T. slightly astringent.
P'rly and vit.	C. w, gyh, rdh: St. w: Trl—op.
P'rly, vit, ad.	C. various: St. w—gy: Lam. tough, highly elastic.
Vit.	C. emerald-gn, apple-gn: St. ywh-gn: Trp—op. T. slightly bitter.
Submet-ad.	C. iron-bk: St. dark cherry-r: Sbtrl—op.
P'rly and res.	C. gnh-w, ywh, gyh: St. w: Trp—trl.
Vit.	C. w: Trp: Very brittle: Partially soluble.
Res; . . ad.	C. w; ywh, gnh, gyh: St. w: Trp—trl.

M : T, when it is the right rhomboidal prism.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Form, M : M.*	*Cleavage.*
*Trona, 141.	2·5—3.	2·110.	Rbdl. 103° 15′.	M perf.
*Glauberite, 162.	"	2·7—2·9.	Rbc. 83° 20′.	P perf.
*Aphanesite, 253.	"	4·1—4·2.	Rbc. 56°.	P em.
Cupreous Anglesite, 249. *Lead ores.*	"	5·3—5·5.	Rbdl. 95° 45′.	M and T perf!
*Vauquelinite, 247. *Lead ores.*	"	5·5—5·8.	Rbc.	
*Chromate of Lead, 245.	"	6—6·1.	Rbc. 93° 40′.	M dist.
*Heulandite, 303. *Amyg., prim.*	3·5—4.	2·15—2·2	Rbdl. 130° 30′.	P perf!
Laumonite, 317 *Prim., amyg*	"	2·3.	Rbc. 86° 15′.	ĕ dist.
Green Malachite, 255. *Copper ores.*	"	4—4·1.	Rbc. 103° 42′.	P perf!
Blue Malachite, 254.	3·5—4·25	3·8—3·9.	Rbc. 98° 50′.	M.
*Huraulite, 216. *Gran.*	about 4.	2·2—2·3.	Rbc. 117° 30′.	None.
Baryto-calcite, 190.	4.	3·6—3·7.	Rbc. 106° 54′.	M perf.
*Bronzite, 300.	4—5.	3·2—3·3.	Rbc. 94°.	P em.
*Turnerite, 372. *Prim.*	4·5—5.		Rbc. 96° 10′.	ĕ and ē.
Pseudo-malachite, 261. *Copper ores.*	4·21—4·3	4·2—4·3.	Rbc. 142° 30′.	Ind.
*Brewsterite, 313. *Amyg., prim.*	5—5·5.	2·1—2·5.	Rbdl. 93° 40′.	P perf.
Datholite, 326. *Amyg., prim.*	"	2·95—3.	Rbc. 77° 30′.	Ind.
*Wagnerite, 170.	"	3—3·2.	Rbc. 95° 25′.	
Anthophyllite, 365. *Prim.*	"	3·1—3·2.	Rbc. 124° 30′.	ĕ perf; M and ē.
Sphene, 415. *Prim.*	"	3·4—3·5.	Rbc. *n* : *n*=136°8′	Ind.
Wolfram, 436. *Prim.*	5.	7·155.	Rbc. 98° 12′.	ĕ perf.
Hornblende, 364. *Prim., volc. &c.*	5—6.	2·9—3·2.	Rbc. 124° 30′.	M perf ē, ĕ sometimes perf.
Pyroxene, 361. *Prim., volc. &c.*	"	3·2—3·4.	Rbc. 87° 5′.	M dist.
*Arfwedsonite, 367. *Prim.*	"	3·4—3·5.	Rbc. 123° 55′.	M perf.
*Æschynite, 429. *Prim.*	"	5·1—5·6.	Rbc. 127°.	
*Acmite, 370. *Prim.*	5·5—6.	3·2—3·4.	Rbc. 86° 56′.	M ind.
Feldspar, 345.	6.	2·3—2·6.	Rbc. 120°. P : T =67° 15′.	P perf, ĕ less so; T ind.
*Amblygonite, 371. *Granite*	"	3—3·1.	Rbc. 106° 10′.	M perf.
*Withamite, 369. *Trap.*	"	3·1—3·3.	Rbdl. 116° 40′.	
Hypersthene, 302. *Prim.*	"	3·3—3·4.	Rbc. 93° 30′.	M and ē.
*Hetepozite, 215.	"	3·3—3·6.	Rbc. (cleavage.)	P and M.
*Brucite, 405. *Prim.*	6—6·5.	2·4—3·2.	Rbc. 112° 12′?	Ind.
Epidote, 368. *Prim.*	6—7.	3·2—3·5.	Rbdl. 115° 24′.	M perf.
Ligurite, 393. *Talcose rock.*	6—7.	3·49.	Rbc. 140°.	
Spodumene, 360. *Prim.*	6·5—7.	3·1—3·2.	Rbc. 93°.	ĕ perf.
Gadolinite, 427. *Granite.*	"	4—4·3.	Rbc. 115°?	Ind.
Euclase, 381. *Prim.*	7·5.	2·9—3·1.	Rbdl. 130° 50′.	M and T perf.

SECTION II. LUSTRE METALLIC.

*Flexible Silver Ore, 523.	very soft		Rbdl. 125°.	
*Miargyrite, 532.	2—2·5.	5·2—5·4.	Rbc. 86° 4′.	M imp.
Wolfram, 436.	5—5·5.	7·1—7·2.	Rbc. 98° 12′.	ĕ perf.

Lustre.	*Color, Diaphaneity, &c.*
Vit.	C. w; ywh: St. w: Trp—trl: Taste sharply alkaline.
Vit.	C. ywh-w, gyh-w: St. w: Sbtrp—trl: T. feebly saline and astring.
P'rly.	C. dark-gn . . b: St. bh-gn: Sbtrl.
Ad, vit.	C. azure-b: St. pale-b: Trl—sbtrl.
Ad.	C. dark-gn; nearly bk: St. siskin-gn, bnh: Sbtrl—op.
Ad.	C. bright r: St. orange-yw: Trl: Sectile.
P p'rly, M vit.	C. w; r, g, bnh: St. w: Trp—sbtrl.
Subp'rly, vit.	C. w; ywh, gyh: Trp—trl. Soon opaque on exposure.
Ad . . vit.	C. gn: St. paler-gn: Trl—sbtrl.
Vit.	C. azure-b: St. pale-b: Trp—sbtrl.
Vit.	C. rdh-yw: Trp.
Vit . . res.	C. w; gyh, ywh, gnh: St. w: Trp—trl.
Met-p'rly—p'rly	C. dark-gn, bn, bronze-like, ash-gy: St. gyh-w and gyh-gn. Foliated.
Ad.	C. y, bn: St. w, gyh-w: Trp—trl.
Ad . . vit.	C. gn: St. paler gn: Trl—sbtrl.
Vit.	C. w; gnh, ywh, rdh: Trl: St. w.
P'rly, M vit.	C. w; ywh, gyh: Trp—trl.
Vit.	C. y; gyh: St. w: Trl.
P'rly—submet.	C. ywh-gy, bnh-gn, clove-bn: St. w: Trl—sbtrl.
Ad; res.	C. bn, bk, y, gyh, gnh: St. w: Trl—op.
Met-ad—submet	C. dark-gyh or bnh-bk: St. dark rdh-bn: Opaque.
Vit, p'rly.	C. gn, bn, bk, w: St. gyh-w: Sbtrp—op.
Vit . . res.	C. gn, bn, gy, w, bkh: St. w—gy: Trp—op.
Vit.	C. bk: Opaque.
Res, submet.	C. bk, dark bnh-yw: St. dark-gy, nearly bk: Trl—op.
Vit, res.	C. bnh-bk, ywh, gnh: St. pale gnh-gy: Sbtrl—op.
Vit; . . p'rly.	C. w, gy; gnh, rdh; bh: St. w—gy: Trp—sbtrl.
Vit . . p'rly.	C. pale-gn; w: St. w: Sbtrp—trl.
Vit.	C. carmine-r, pale straw-yw: St. w: Trl.
P'rly; . . met.	C. gyh-, gnh-bk; copper-red: St. gnh-gy: Sbtrl—op.
Res.	C. gnh-, bh-gy; violet after exposure, with submetallic lustre.
Vit . . res.	C. yw, bn, r, apple-gn: St. w; slightly ywh: Trl—sbtrl.
Vit . . p'rly.	C. gn; yw, gy, rdh-w: St. gy—w: Sbtrp—trl.
Vit.	C. apple-gn; often speckled: St. gyh-w: Trp—trl.
P'rly.	C. ywh-w, gnh-w: St. w: Trl—sbtrl.
Vit . . res.	C. dark gnh-bk: St. gnh-gy: Sbtrl—op.
Vit.	C. pale mountain-gn, bh, w: Trp—sbtrp: Fragile.

SECTION II. LUSTRE METALLIC.

Met.	C. externally nearly bk: Lam. flex.
Submet-ad.	C. iron-bk: St. dark cherry-red: Very sectile.
Submet.	C. dark gyh-, or bnh-bk: St. dark rdh-bn: Opaque.

CLASS TRICLINATA.

Names of Species.	_Hardness._	_Sp. Grav._	_P : M, P : T, M : T._	_Cleavage._
Blue Vitriol, 157.	2·5.	2·2—2·3.	109° 32′, 128° 27′, 149° 2′.	Imp.
Schiller Spar, 299. _Serpentine._	3·5—4.	2·6—2·7.	M : T between 135° and 145°.	Foliated.
Tabular Spar, 359.	4—5.	2·7—2·9.	93°40′, 126°? 95°15′	Perf. in one direction.
*Babingtonite, 363. _Granite_	5·5—6.	3·4—3·5.	92°34′, 88°, 112°30′	P perf.
*Latrobite, 349. _Prim._	5·5—6·5.	2·7—2·8.	91° 9′, 98°30′, 93°30′	P, M, T.
Kyanite, 374. _Prim._	5—7.	3·5—3·7.	93° 15′, 100° 50′, 106° 15′.	M dist.
*Pericline, 346. _Prim._	6.	2·5—2·6.	93° 19′, 114° 45′, 120° 18′.	P and T perf.
Albite, 347. _Prim._	"	2·6—2·7.	93°30′, 115° 5′, 117° 53′.	P perf, M and T less so.
*Anorthite, 348. _Volc._	"	2·65—2·7	94° 12′, 110° 57′, 117° 28′.	P and M.
Labradorite, 344. _Prim., volc._	"	2·65—2·8	94° 30′, 119°, 115°.	P and M.
*Allanite, 423.	"	4—4·1.	M : T=116°.	Imp.
Manganese Spar, 356. _Prim_	6—7.	3·4—3·7.	93° to 94°, 112° 30′, 121°.	P perf.
*Diaspore, 376. _Prim._	6—6·5.	3·4—3·5.	71° 30′, 78° 40′, 64° 54′.	Cleavage in two directions.
*Axinite, 396. _Prim._	6·5—7.	3·2—3·3.	134° 40′, 115° 17′, 135° 10′.	Imp.

CLASS TETRAXONA.

SECTION I. LUSTRE UNMETALLIC.

Names of Species.	_Hardness._	_Sp. Grav._	_Form, R : R._	_Cleavage._
Nitrate of Soda, 152.	1·5—2.	2·0964.	Rbdn 106° 33′.	R perf.
*White Copperas, 155.	"		Hexag.	
*Copper Mica, 265. _Cop. ores._	2.	2·5—2·7.	Rbdn. 69° 30′.	a eminent.
Black Mica, 297.	2—2·5.	2·8—3.	Hex.	P em!
*Light Red Silver, 534.	"	5·4—5·55	Rbdn. 170° 36′.	Imp.
*Cinnabar, 535.	"	7·8—8·1.	Rbdn. 71° 47′.	_a_ perf!
Pinite, 289. _Prim._	"	2·7—2·8.	Hex.	P sometimes dist.
*Cronstedtite, 227.	2·5.	3·3—3·4.	Rbdn.	a em.
*Dark Red Silver, 533.	2·5—3.	5·75—5·9	Rbdn. 108° 18′.	Imp.
*Vanadate of Lead, 243. _Lead ores._	2·75.	6·6—7·5.	Hex.	
Calcareous Spar, 180.	3.	2·5—2·8.	Rbdn. 105° 5′.	R perf!
*Fahlunite, 290.	"	2·6—2·7.	Hex.	P dist.
*Mimetene, 241. _Lead ores._	2·75—3·5	6·4.	Hex.	M imp.
*Carbonate of Lime and Soda, 184.	3—3·5.	2·9—3.	Rbdn.	R.
*Dreelite, 192.	3·5.	3·2—3·4.	Rbdn. 93° or 94°.	R ind.
*Diallogite, 213.	"	3·5—3·6.	Rbdn. 106° 51′.	R.
Dolomite, 182.	3·5—4.	2·8—3.	Rbdn. 106° 15′.	R perf.

CLASS TRICLINATA.

Lustre.	*Color, Diaphaneity, &c.*
Vit.	C. sky-blue : St. w : Sbtrp—trl. Taste met. astringent.
Met-p'rly—vit.	C. dark-gn, pinchbeck-bn : St. gyh-w, ywh. Sbtrl.
Vit..p'rly.	C. w ; gyh, rh, ywh, bnh : St. w . Sbtrp—sbtrl.
Vit, splend.	C. dark gnh-bk : Trl—op.
Vit.	C. pale-red or pink. Sbtrl—op.
P'rly—vit.	C. b, w, gnh : St. w : Trp—trl. Crystals usually long and thin.
P'rly ; .. vit.	C. w ; ywh, rdh : St. w : Sbtrp—sbtrl.
Vit . , p'rly.	C. w ; gyh, rdh, bnh : St. w : Trp—sbtrl.
P'rly . . vit.	C. w : St. w : Trp—trl.
P'rly. M & T vit.	C. w ; gyh, rdh, bnh ; bh. and gnh. iridescence : St. w : Sbtrl.
Submet—res.vit.	C bnh-, or gnh-bk : St. gnh-gy . Sbtrl—op.
Vit.	C. pale flesh-r : St. w : Trp—op : Becomes bk. on exposure.
Vit, splend.	C. gnh-gy or hair-bn : Trl—sbtrl.
Vit, splend.	C. clove-bn, bh, gyh, gnh : St. w. Trp—trl. Crystals very flat and acute.

CLASS TETRAXONA.

SECTION I. LUSTRE UNMETALLIC.

Lustre.	*Color, Diaphaneity, &c.*
Vit.	C. w : St. w : Trp : Taste cooling. Deflagrates on coals.
	C. w, pale violet : Taste astringent and metallic, nauseous.
a p'rly, R vit.	C. gn : St. gn, paler than color : Trp—trl. Sectile.
P'rly, submet.	C. dark gn, bn, nearly bk : St. gyh w : Thin. lam. elastic.
Ad.	C. cochineal-red : St. r : Sbtrp—sbtrl.
Ad . . met.	C. cochineal-red—lead-gy : St. scarlet-red. Lam. easily separated.
Res p'rly ; glim.	C. bnh-yw, straw-yw ; pearl-gy, rdh-bn : St. gyh-w . Sbtrl—op. Brit.
Vit splend.	C. bnh-bk : St. dark leek-gn : Opaque : Lam elastic.
Met-ad.	C. iron-bk—coch-r : St. coch-r : Trl—op : Sectile.
Res.	C. straw-yw—rdh-bn : St. w : Opaque.
Vit.	C. w, gy, rdh, ywh : St. gyh-w : Trp—trl.
Res ; . . vit.	C. gn ; . . bnh, bk : St. gyh-w : Opaque.
Res.	C. pale yw—light bn : St. w : Sbtrp—opaque.
Vit.	C. w—gyh, ywh : St. w : Trl—trp.
P'rly.	C. and St. w.
Vit . . p'rly.	C. rose-r ; bnh : St. w : Trl—sbtrl.
Vit—p'rly.	C. w ; gnh, rdh, bnh : St. w—gy . Sbtrp—trl. Cryst. often with [curved faces.

Names of Species.		*Hardness.*	*Sp. Grav.*	*Form, R : R.*	*Cleavage.*
Ankerite, 183.		3·5—4.	2·9—3·2.	Rbdn. 106° 12′.	R.
Spathic Iron, 211.		"	3·7—3·9.	Rbdn. 107°.	R perf.
Pyromorphite, 241.		"	6·5—7·1.	Hex.	M ind.
*Margarite, 296.	*Prim.*	3·5—4·5.	3—3·1.	Hex.	P perf.
*Levyne, 324.	*Trap.*	4.	2·15—2·2	Rbdn. 79° 29′.	R ind.
Flucerine, 195.	*Prim.*	"	4·7.	Hex.	P.
Chabazite, 323.	*Amy. & prim*	4—4·5	2—2·1.	Rbdn. 94° 46′.	R ind.
Gmelinite, 325.	*Amyg.*	"	2—2·2.	Hex.	Imp.
•Beudantite, 550.		"		Rbdn. 92° 30′.	a perf.
*Pyrosmalite, 226.	*Prim.*	"	3—3·1.	Rbdn.	a em.
Rhomb Spar, 185.		"	3—3·2.	Rbdn. 107° 22′.	R perf!
*Alum Stone, 166.	*Volc.*	5.	2·6—2·8.	Rbdn. 92° 50′.	a.
Apatite, 169.		"	3—3·3.	Hex.	Imp.
*Dioptase, 257.		"	3·278.	Rbdn. 126° 17′.	R.
Calamine, 207.		"	4·3—4·5.	Rbdn. 107° 40′.	R perf.
Troostite, 357.	*Prim.*	5·5.	3—3·1.	Rbdn. 115°.	*e* perf.
*Cerite, 421.	*Prim.*	"	4·912.	Rbdn.	
•Nepheline, 341.	*Volc.*	6.	2·4—2·6.	Hex.	Imp.
*Eudialyte, 410.	*Prim.*	"	2·85-2·95	R. 73° 40′.	a perf.
Quartz, 397.		7.	2·6—2·7.	Rbdn. 94° 15′.	Imp.
Turmaline, 379.	*Prim.*	7—8.	3—3·1.	Rbdn. 133° 26.	Ind.
Beryl, 380.	*Prim.*	7·5—8.	2·6—2·8.	Hex.	P ind.
•Phenacite, 382.	*Prim.*	"	2·9—3.	Rbdn. 115° 25′.	R.
Sapphire, 387.	*Prim.*	9.	3·9.	Rbdn. 86° 6′.	a perf.

SECTION II. LUSTRE METALLIC.

Molybdenite, 524.	*Prim.*	1—1·5.	4·5—4·8.	Hex.	P em!
Plumbago, 547.		1—2.	2·0891.	Hex.	P em.
•Molybdic Silver, 511.		Soft.	7·2—8.	Rbdn.	R perf.
•Telluric Bismuth, 527.		2.	7·5—7·6.	Rbdn.	R perf.
•Native Tellurium, 472.		2—2·5.	5·7—6·1.	Hex.	Imp.
•Cinnabar, 535.		"	7·8—8·2.	Rbdn. 71° 47′.	*a* perf.
*Dark Red Silver, 533.		2·5.	5·7—5·9.	Rbdn. 108° 18′.	R imp.
•Polybasite, 508.		2—3.	6·2—6·3.	Rbdn.	Ind.
*Zinkenite, 514.	*Antim. ores*	3—3·5.	5·3—5·4.		Ind.
•Native Antimony, 473.		"	6·6—6·8.	Rbdn. 117° 15′.	a perf! R dist.
•Native Arsenic, 475.		3·5.	5·65—6.	Rbdn. 114° 26.	a imp.
Magnetic Pyrites, 489.		3·5—4·5.	4·6—4·7.	Hex.	P perf.
Crichtonite, 455.	*Prim.*	5—5·5.	4·4—4·6.	Rbdn. 61° 20′.	a.
*Antimonial Nickel, 478.		5·5.		Hex.	
Specular Iron, 452.		5·5—6·5.	5—5·3.	Rbdn. 85° 58′.	R and a ind.
•Mohsite, 456.	*Prim.*	6—6·5.		Rbdn. 73° 43′.	Ind.
Iridium, 460.		6—7.	19—21·5.	Hex.	P.

Lustre.	*Color, Diaphaneity, &c.*
Vit.	C. w. gyh, rdh, bnh : St. w, bn : Trl—sbtrl.
Vit . . p'rly.	C. y, gy, ash-gy, bn, rdh : Darkens on exposure.
Res.	C. gn, bn ; ywh, rdh, gyh : St. w ; ywh : Sbtrp—sbtrl.
P p'rly.	C. pale pearl-gy, rdh-w, ywh : St. w : Trl—sbtrl.
Vit.	C. w—rdh : St. w : Sbtrp—op.
	C. dark b, r, ywh ; deeper when wet : St. w, or slightly ywh.
Vit ; splend.	C. w, rdh-w ; ywh : St. w : Sbtrp—trl.
Vit.	C. w . . flesh-r : St. w : Trp—trl.
Res.	C. bk ; in thin fragments, deep bn and trl : St. gnh-gy.
a p'rly.	C. pale bn, gn, gy : St. paler : Trl—op.
Vit . . p'rly.	C. w, gy, bnh, ywh ; brown on exposure : St. w—gy : Trp—trl.
P'rly and Vit.	C. w ; rdh, gyh : St. w : Trp—sbtrl.
Vit . . res.	C. light gn, wh, bh : St. w : Trp—op.
Vit . . res.	C. emerald-gn, bkh-gn : St. gn : Trp—trl.
Vit . . p'rly.	C. w ; gyh, gnh, bnh : St. w : Sbtrp—trl.
Vit . . res.	C. pale gn, y, gy, r, bn : St. w : Trp—trl.
Ad.	C. clove-bn, cherry-r : St. gyh-w : Sbtrl—op.
Vit . . p'rly.	C. w, ywh : St. w : Trp—op.
Vit.	C. bnh-r, rose-r : St. w : Sbtrl—op.
Vit.	C. various : St. w, gyh : Trp—trl—op. Crys. mostly hexagonal prisms terminated by pyramids.
Vit.	C. b, bk, bn, gn, r ; often brt : St. w : Interior and exter. often dif. col.
Vit.	C. gn ; bh, ywh, w : St. w : Trp—sbtrl—op.
Vit.	C. w, wine-yw, rdh : St. w : Trp—op.
Vit.	C. b, r, gn, yw, bn, gy, w : St. w : Trp—trl.

SECTION II. LUSTRE METALLIC.

Met.	C. and St. lead-gy : Soils paper—trace on porcelain gnh : Lam. flex.
Met.	C. iron-bk, dark steel-gy : St. bk; shining : Sectile. Soils paper. Trace same as color.
Met.	C. pale steel-gy : St. dark iron-bk.
Met.	C. pale steel-gy. Soils paper. Lam. elast. Not very sectile.
Met.	C. and St. tin-white : Brittle.
Submet—ad.	C. lead-gy—cochineal-red : St. scarlet : Sbtrp—sbtrl.
Met-ad.	C. iron-black . . cochineal-red : St. coch-red : Op. Sectile.
Met. splend.	C. iron-bk : St. bk : Sectile : Crystals short hexag. prisms.
Met.	C. and St. steel-gy : Op.
Met.	C. and St. tin-w : Not ductile.
Met.	C. and St. tin-w ; tarnish soon to dark-gy.
Met.	C. bronze-yw, copper-r : St. dark gyh-bk : Tarnish : Slightly attracted by magnet.
Met.	C. dark iron-bk : St. bk : Brittle : Slight action on the needle.
Met. splend.	C. light copper-r ; . . violet : St. rdh-bn : Not mag : Brittle.
Met.	C. dark steel-gy—iron-bk : St. cherry-r—rdh-bn : Often irisedly tarnished.
Met. splend.	C. iron-bk : Op.
Met.	C. tin-w, pale steel-gy : St. similar : Brittle.

CLASSIFICATION II., INDEPENDENT OF CRYSTALLIZATION.

The peculiarities in this classification will be elucidated in the following sections. The annexed is a general view of the several subdivisions.

CLASS I. EPIGÆA.

G. under 3·8. Solid individuals, having an acid, alkaline, or saline taste.

SECTION 1. FLUIDS.

Liquid or gaseous.

SECTION 2. SOLIDS.

Subsection A. Easily soluble.
a. Taste like that of alum. Color white, or grayish. No effervescence with acids.
b. Taste alkaline. Color white, or grayish. Effervescence with acids.
c. Taste sweetish-alkaline; rather feeble.
d. Taste purely saline.

CLASS EPIGÆA.

SECTION I. FLUIDS.

Names of Species.	*Sp. Grav.*	*Odor.*	*Taste.*
Hydrogen, 122.	0·0694.		None.
Carburetted Hydrogen, 121.	0·555.	Empyreumatic.	
Nitrogen, 125.	0·9757.		
Atmospheric Air, 126.	1.		
Sulphuretted Hydrogen, 124.	1·1912.	Fetid.	
Muriatic Acid, 129.	1·2847.	Disagreeable.	Acid.
Carbonic Acid, 127.	1·5245.		
Phosphuretted Hydrogen, 123.	1·7618.	Alliaceous.	Bitter.
Sulphurous Acid, 128.	2·22.	Sulphureous.	
Water, 130.	1.		
Sulphuric Acid, 131.	1·1—1·85.		Intensely Acid.

SECTION II. SOLIDS.

Subsection A. Easily soluble.

a. Taste like that of alum. *Color* white, or grayish. No effervescence with acids.

Names of Species.	*Hardness.*	*Sp. Gravity.*	*Structure.*	*Lustre.*
*Solfatarite, 136. *Volc. &c.*	2—3.	1·88.	Fib., pulv., mas.	P'rly, vit.
Native Alum, 135.	2—2·5.	1·75.	I: Effl.	Vit. p'rly.
*Ammonia Alum, 138.			I: Fib.	Resinous.
Magnesia Alum, 137.			Fib, mas.	Shining.

e. Taste saline and bitter. Color white, or with a slight tinge of blue or green.
f. Taste saline and cooling. Color white. Deflagrates on burning coals. Effervesces with heated sulphuric acid.
g. Taste astringent, metallic. Often deeply colored. No effervescence with acids.
Subsection B. Solubility inconsiderable.

CLASS II. ENTOGÆA.

G. above 1·8. Tasteless.

SECTION 1. LUSTRE UNMETALLIC.

Subsection A. Streak white, or grayish-white.
Subsection B. Streak colored.*

SECTION 2. LUSTRE METALLIC.

CLASS II. HYPOGÆA.

G. under 1·8. Includes resinous and carbonaceous minerals.

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* A few of the species present, in their different varieties, sometimes a white, and in others a colored streak, and consequently may be found in each of these subsections.

CLASS I. EPIGÆA.

SECTION I. FLUIDS.

Inflammable—light of flame feeble, blue.
Inflammable—light of flame blue, with a tinge of yellow.
Not inflammable—extinguishes combustion. Insoluble in water.
Not inflammable—supports combustion and life.
Strong odor of putrescent eggs.
Corrosive—usually in solution in water. Precipitate with nitrate of silver.
Not corrosive—extinguishes combustion. Soluble. Precipitates lime from its solution.
Inflames when brought in contact with the atmosphere.

Effervesces with carbonate of lime or common salt.

SECTION II. SOLIDS.

Subsection A. Easily soluble.

a. *Taste* like that of alum. *Color* white, or grayish. No effervescence with acids.

Color, Diaphaneity, &c.	*Blowpipe.*
C. w: Sbtrp—sbtrl: Sol. ½ weight of water at 60°.	Fus!, int.
C. w: Trp—trl: Sol. 16 times weight of cold water.	Fus!, int.
C. and St. gyh-w: Trp—trl.	
C. and St. snow-w.	

b. Taste alkaline. *Color* white, or yellowish. Effervescence with acids.

Names of Species.	*Hardness.*	*Sp. Gravity*	*Structure.*	*Lustre.*
*Natron, 140.	1—1·5.	1·1—1·5.	IV : Effl, fol, mas.	Vit.
*Gay-Lussite, 139.	2—3.	1·9—2.	IV : Fol.	Vit.
*Trona, 141.	2·5—3.	2·1—2·15.	IV : Fib; mas.	Vit.
c. Taste sweetish-alkaline.				
*Borax, 134.	2—2·5.	1·7—1·75.	IV : mas.	
d. Taste purely saline.				
Common Salt, 142.	2.	2·2—2·3.	I : Fol, mas.	Vit.
e. Taste saline and bitter. *Color* white, or with a slight tinge of blue or green.				
*Glauber's Salt, 143.	1·5—2.	1·4—1·5.	IV : Effl. crusts.	Vit.
*Sal Ammoniac, 149. *V. &c.*	"	1·5—1·6.	I : Imit, crusts, effl.	Vit.
*Mascagnine, 147. *Volc.*	"		Mas, pulv.	Vit.
*Thenardite, 144.	"	2·7—2·8.	III : crusts.	Vit.
*Aphthitalite, 148. *Volc.*	2·5—3.	1·7—1·8.	Mam, mas.	Vit.
*Epsom Salt, 145.	2—2·5.	1·7—1·8.	III : Fib; Imit; effl.	Vit, p'rly.
*Reussite, 146.			III : Mealy effl.	
Nitrate of Lime, 151.		1·62.	Cryst. effl. silken tufts.	
Nitrate of Magnesia, 150.		1·74.	Effl.	
f. Taste saline and cooling. *Color* white. Deflagrates on burning coals.				
Nitrate of Soda, 152.	1·5—2.	2—2·1.	VI : Effl.	Vit.
Nitre, 153.	2.	1·9—2.	III : Fib, crust.	Vit.
g. Taste astringent metallic. Often deeply colored. No effervescence with acids.				
Copperas, 154.	2.	1·8—1·9.	IV : Im; pulv.	Vit.
*Botryogen, 161.	2—2·5.	2—2·1.	IV : Imit, mas.	Vit.
White Vitriol, 158.	"	2—2·1.	III : Effl. crusts.	Vit.
*White Copperas, 155.	"	2—2·1.	VI : Mas.	
*Yellow Copperas, 156.				P'rly.
*Cobalt Vitriol, 159.			IV : Imit : crusts.	Vit, p'rly.
*Blue Vitriol, 157.	2·5.	2·2—2·3.	V : Mas.	Vit.
*Johannite, 160.	"	3·1—3·2.	IV : Agg. cryst.	Vit.
Subsection B. Solubility inconsiderable. *Taste* weak.				
*Boracic Acid, 132. *Volc.*		1·4—1·5.	VI : cryst. grains; Im.	P'rly.
*Arsenous Acid, 133.	1·5.	3·698.	I : Imit.	Vit . . silky.
*Glauberite, 162.	2·5—3.	2·75—2·85.	IV.	
Polyhalite, 163.	3·5.	2·7—2·8.	III : Col, mas.	Res, p'rly.

b. *Taste* alkaline. *Color* white, or yellowish. Effervescence with acids.

Color, Diaphaneity, &c.	*Blowpipe.*
C. w, gyh, ywh: Efflorescent.	Fus! [inf·
C. w, ywh: Trp—trl: Not efflorescent. Partially soluble.	Dec, fus! glob·
C. w, ywh, gyh: not effl. or deliq: Easily soluble.	Dec, fus!

c. *Taste* sweetish-alkaline.

C. w, gyh, gnh: Trp—trl: Effl. slowly.	Int, fus. trp. vit. glob.

d. *Taste* purely saline.

C. w, gyh, bh, rdh: Effervesce with sulphuric acid.

e. *Taste* saline and bitter. *Color* white, or with a slight tinge of blue or green.

C. w, gyh: Trp—op: T. cool, then feebly saline and bitter: Efflor. No effervescence.	Watery fusion.
C. w, ywh, gyh, gnh: Trp—trl: T. acute and pungent: Not deliquescent: Ef. sul.	Vol. w-fumes. [heat.
C. ywh, gyh-w: Sbtrp—trl: T. pungent, bitter: Slowly del: No ef.	Decomp. at red
C. w: T. saline and bitter: No ef. with acids.	Fus. at red heat.
C. w, bh, gnh: Trl: T. pungent, saline, bitter: Ef. sul.	Fus!
C. w: Trl: T. very bitter, saline.	Del; fus. dif.
C. snow-w: T. saline, bitter.	[slight det.
C. w, gy: Very deliquescent.	Watery, fus., [scarcely det.
C. w: deliquescent.	Watery fus.,

f. *Taste* saline and cooling. *Color* white. Deflagrates on burning coals.

C. w: Trp—trl: T. more bitter than Nitre: Deliquescent: Ef. hot sul.	defl. with deep yw. light.
C. w: Trp—trl: Not deliquescent or efflorescent: Ef. hot sul.	

g. *Taste* astringent, metallic. Often deeply colored. No effervescence with acids.

C. gn; wh; yw. on exposure: St. w: Sbtrp—trl: T. sweetish astringent and metallic.	*Bor*, gn-glass.
C. hyacinth-r, ochre-yw: St. yw, shining: T. slightly astringent.	Becomes mag.
C. w: Trl: T. astringent, nauseous, metallic: Very soluble.	Int., rdh-yw.
C. w; tinge of violet: T. sweetish astringent: Hot sol. precips. ox. iron.	
C. yw: Trl.	
C. flesh-r, rose-r: Sbtrp—trl: T. astringent.	
C. Sky-b: St. w: Sbtrp—trl: T. metallic and nauseous.	*Bor*, b.
C. gn: St. ywh-gn: Sbtrp—op: T. bitter, somewhat astringent.	

Subsection B. Solubility inconsiderable. *Taste* weak.

C. gyh-, ywh-w: Feel smooth and unctuous: T. acidulous and bitter.	Fus. in candle; flame gn.
C. w, ywh, rdh: St. w: T. sweetish-astringent.	On char. vol. alliac. odor.
C. ywh-, gyh-w: St. w: Sbtrp—trl: Loses trp. in water.	Dec. w. enamel,
C. gy—brick-red; ywh: Trl—op: Taste saline and bitter weak.	Fus! In candle, op, bnh.

CLASS II. ENTOGÆA.

SECTION I. LUSTRE UNMETALLIC.

Subsection A. *Streak* white, or grayish-white.

Names of Species.	*Hardness*	*Sp. Grav.*	*Structure.*	*Lustre.*
Talc, 295. *Prim., amyg.*	1—1·5	2·7—2·8	III, fol : mas.	P'rly; earthy.
*Horn Silver, 273. *Prim.*	"	5·5—5·6	I. Crusts; mas.	Res; . . ad.
*Iodic Silver, 275.	"		Fol-mas.	Res.
Hydro-Magnesite, 187. *Serpentine.*	1—2	2·8—2·81	Pulv, crusts.	Dull.
Fuller's Earth, 556.	1—2		Earthy.	Dull.
*Kollyrite, 277.	?		Like clay.	Vit.
*Horn Quicksilver, 274.	1—2	6·4—6·5	II. Mas.	Ad.
*Bismuth Ochre, 205. *Prim*		4·3—4·4	Earthy, mas, pulv.	Dull, earthy.
*Scarbroite, 278. *G-wacke.*	?	1·4—1·5	Mas.	Dull.
*Websterite, 570. *Clay.*	1·5—2	1·6—1·7	Ren, mas.	Dull, earthy.
*Halloylite, 276.		1·8—2·1	Mas.	Waxy.
Sea Foam, 288.	1·5—2		Mas.	
*Oxalate of Lime, 164. *Coal.*		2·1—2·5	Earthy.	Dull.
Native Magnesia, 294.	1·5—2	2·3—2·4	VI, fol: Lam.	P'rly.
Gypsum, 176.	1·75—2	2·25-2·35	IV, fol: Lam, stel, fib, mas.	P'rly, vit.
*Hydroboracite, 179.	2	1·9	Fib, fol.	
Nemalite, 293. *Serpentine.*	"	2·3—2·5	Slender fib.	P'rly.
*Cotunnite, 234. *Volc.*	Soft.	1·8—1·9	Acic. cryst.	Ad; . . p'rly.
*Haidingerite, 175. *Prim.*	1·5—2·5	2·8—2·9	III, fol : Bot.	Vit.
*Mellite, 539. *Coal.*	2—2·5	1·5—1·6	II. Mas.	Res . . vit.
*Kerolite, 285. *Serpentine.*	"	2—2·2	Ren, glob; struct. lam: Crusts. [mas.	Res, vit.
*Pharmacolite, 174.	"	2·6—2·8	IV, fol: Stel, fib, bot,	P'rly and vit.
Pinite, 289. *Prim.*	2—2·5	2·7—2·8	VI. Hex. prisms.	Res . . p'rly, [weak.
*Agalmatolite, 284.	"	2·8—2·9	Mas.	Dull.
Common Mica, 298. *Prim.*	"	2·8—3	IV, fol!: Fol-mas.	P'rly, vit. ad.
Black Mica, 297. *Prim., Vesuv.*	"	2·8—3	VI, fol!: Fol-mas.	P'rly.
*Leadhillite, 236. *Lead ores.*	"	6·2—6·3	IV, cleav: Mas.	P'rly, res . . [ad.
*Dyoxylite, 237. *Lead ores.*	"	6·8—7	IV, fol: Col; mas.	P'ly, ad . . res.
socolla, 256. *Copper ores.*	2—3	2—2·4	Bot, mas.	

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CLASS II. ENTOGÆA.

SECTION I. LUSTRE UNMETALLIC.

Subsection A. *Streak* white, or grayish-white.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. gn, gnh-w, w: Sbtrp-trl: Feel soapy: Sectile: Lam. flexible.		Lose C. Infus. or nearly so.
C. pearl-gy, bh, gnh; on exposure bnh: St. shining: Trl—sbtrl.	Insol. *nit.*	Fus. in candle, mur. fumes.
C. w, ywh-gn; on exposure bh: St. submet: Lam. flex.: Silvery-w if polished.		On char. fus!!, violet fumes.
C. & St. w: Op: Adheres to the tongue.	*Nit.* ef.	Infus.
C. w, gyh, gnh: Feel greasy: Pulv. in water, no plasticity.		Fus. gy. op. enam.; with soda ef. op. bead.
C. w: Trl—opl: Fr. earthy: Splits into columnar masses like starch, when calcined.	*Nit.* sol., no ef.	Unalt; evolves water.
C. ywh-gy; ywh-, gyh-w: Trl—sbtrl: Sect.		On char. vol.
C. gnh-yw, straw-yw, gyh-w.	*Nit.* sol.	On char. met.; vol.
C. pure w: Odor argil.: Polished by nail: Absorbs water if immersed in it: Trp. not increased.		
C. white: Op: Fr. earthy: Adheres to the tongue: Feel meagre.	Sol., no ef.	Fus. dif.
C. w, bh: Sbtrl: Adheres to tongue: More trp. in water.	*Sul.* gel!	
C. gyh-w, rdh: Feel unctuous: Absorbs water, forms paste without plasticity.		Whitens.
C. yw: Op.	*Nit.* sol., no ef. ywh.	Bkns in candle; vegeta. odor; easily decomposed
C. w, gnh, gyh, bh: Trl—sbtrl: Lam. flex.	Sol., no ef.	Wh'ns. Friable, infus.
C. w, bh, rh, yh, gyh: Trp—trl: Lam. flex.; inelast.	No action.	Wh'ns! Exf. friable. Fus dif.
C. w, with red spots: Thin plates trl: Like fib. and fol. gypsum.		Fus.
C. gyh-, bh-w, ywh: Trl—sbtrl: Fibres elastic, separable. Becomes white, opaque, and brittle, on exposure.	Sol. *nit.*, no ef.	Op, friable.
C. w.		Fus!, b. flame; on char. [w. fumes.
C. w: Trp—trl: Lam. slightly flexible.	Sol. *nit.*, no ef.	
C. honey-yw, rdh, bnh: Trp—trl: Sectile.		Wh'ns in candle; not [burn.
C. w, gn, bn: Trp—trl: Not adhere to tongue: Odor argil.; Feel soapy.		
C. w, gyh, ywh, rdh: Trl—op.	*Nit.* sol., no ef.	W. fumes, arsen. odor.
C. gy, gyh-gn, bn: Op.		Whitens.
C. w, gy, gn, yw, r, bn; none bright; Sbtrl: Feel greasy: Sectile.	*Sul.* partly sol.	Whitens; infus.
C. various; often bright: Trp—sbtrl: Lam., elastic! tough. Presents two axes of polarization.		Op; fus dif!—infus.
C. dark-gn, bn, nearly bk: Lam. elastic! tough. Presents one axis of polarization.		Op; fus dif!—infus.
C. ywh-w; pale gyh, gnh, ywh: Trp—trl.	*Nit.* ef!, w precip	Int, yw; w. on cooling.
C. gnh-w, ywh-w; gyh: Trp—trl: Lam. flexible.	*Nit.* sol., no ef.	Fus; glob w. on cooling.
C. emerald and pistachio-gn; . . sky-blue; bnh: Sbtrl.	*Nit.* sol., no ef.	B'kns in outer flame; inf.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
•Chenocoprolite, 220. *Prim*	2—3		Mammillary.	Res, shining.
•Cryolite, 165. *Prim.*	2·25—2·5	2·9—3	III, fol : Mas.	Vit . . p'rly.
Picrosmine, 291. *Prim*	2·5—3	2·5—2·7	III. cleav ; fib, mas.	P'rly, vit.
•Hopeite, 210.	"	2·7—2·8	III, cleav.	Vit and p'rly.
•Arsen.Iron, 218. *Iron ores*	?	?	II : Mas.	
•White Antimony, 203. *Ant'y ores*	2·5—3	5·5—6	III, cleav : Mas.	Ad . . p'rly.
Anglesite, 238. *Lead ores.*	"	6·25—6·3	III, lam : Mas.	Ad . . vit, res.
•Cerasite, 235 *Lead ores*	"	7—7·1	III : Col, rad	P'rly, ad.
Molybdate of Lead, 242. *Lead ores.*	2·75—3	5·7—5·8	II, crys. often tab : Mas.	Res.
Corneous Lead, 233. *Lead ores*	"	6—6·1	II : Mas.	Ad.
•Vanadate of Lead, 243. *Lead ores*	"	6·6—6·7	VI . Glob, crusts, mas.	Res.
Tungstate of Lead, 244. *Lead ores.*	"	7·9—8·1	II : Mas.	Res.
•Allophane 281	3	1·8—1·9	Ren, mas.	Vit . . res ; on fract.splend.
•Fahlunite, 290.	"	2·6—2·7	VI : Mas.	Res, vit.
Roselite, 178.	"		III, fol	Vit.
Polysphærite, 252.	"	5·89—6·1	Rounded balls, rad	Res.
Calcareous Spar,† 180.	2·75-3·25	2·5—2·8	VI, cl ! : fib, imit, mas.	Vit, p'rly.
Anhydrite, 177	2·75—3·5	2·8—3	III, fol : Lam, fib, mas.	P'rly, vit.
Celestine, 189.	"	3·8—4	III : Fib, lam, mas.	Vit, res.
Heavy Spar, 193.	"	4·3—4·8	III : Fib, lam, mas.	Vit, p'rly, res.
Serpentine, 283	2·5—3·5	2·4—2·6	III : Mas, fib fol	Res—earthy.
Sulphato-Carbonate of Baryta, 194.	2·75-3·25	4·141	Hexag. prisms	Vit
•Mimetene, 241 *Lead ores*	2·75—3·5	6·4—6·5	VI . Imit : Mas.	Res.
Gibbsite, 280	3—3·5	2·4	Stalac, small botryoid.	Faint.
*Carb. Lime & Soda, 184	"	2·92	VI, cleav : Lam. mas.	Vit.
White Lead Ore, 232.	"	6·1—6·5	III. Col ; mas, gran.	Ad—res.
Witherite, 191.	3—3·75	4·1—4·35	III : Imit, col, mas.	Vit . . res.
•Mesolite, 311. *Amyg*	3·5	2·3—2·4	III, cl : Col, lam, rad, crest-like aggreg; mas.	
*Dreelite, 192	"	3·2—3·4	VI not cleav	P'rly : Splen. on fract.
•Diallogite, 213.	"	3·5—3·6	VI, cleav : Bot, mas	Vit, p'rly.
Strontianite, 188.	"	3·6—3·65	III, cleav : Fib, mas	Res : . . vit
*Junkerite, 212.	"	3·8—3·85	III.	
Spathic Iron, 211.	3—4	3·7—3·9	VI, cleav ! fol. mas.	Vit. p'rly.
•Wavellite, 173.	3·25—4	2·3—2·4	III : Delicately col-hemisph, stel. fib.	P'rly, vit.

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† Some varieties of this species present very low degrees of hardness; they may be readily distinguished by their strong effervescence with acids, their infusibility,

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. yw, pale-gn.		Arsen; fus, bkh mag. scoria.
C. w; rh, ywh: Sbtrp—trl: More trp. in water: Feel greasy: Odor argillaceous.		Fus. in candle.
C. gnh-w, gnh-gy, leek-gn: Sbtrl: Very sectile.		Infus; evolves water; op.
C. gyh-w: Trp—trl.	*Nit.*, *mur.* sol., no ef.	Fus. trp. glob., flame gn. *Soda*, cop. & zinc fumes.
C. pale.		
C. w; . . pale-r, ash-gy: Sbtrp—trl: Sect.		Fus. in candle; on char. vol, produces w. coat'g.
C. ywh-, gyh-, gnh-w; yw, gy: Trp—trl.	Not sol. *nit.*	Dec; Fus. w. slag.
C. ywh-w, rdh: Trl—op.: Brittle.		Fus!; on ch. mur. fumes.
C. wax-yw, or orange-yw, ywh-w: Sbtrp—sbtrl.		Dec; darkens; on char. lead.
C. w; pale-gy, yw, gnh: Trp—trl.		Fus! yw glob; w. on cooling: On char. lead.
C. light bnh-yw, straw-yw, rdh-bn: Sbtrl—op.	*Sul.*, gn sol.; *nit.* yw.	Fus: on cool'g again yw.
C. gn, gy, bn, r: Trl—sbtrl.		Fus; ox. of lead on char.
C. pale-b; gn, bn, yw: Trl: Very brittle.	Gelat. with acids.	Lose color, pulv; gn. flame; infus.
C. gn, dark-bn, bk: Op: St. gyh-w.		Gy; fus. dif!!; *bor.* slow sol, colored globule.
C. deep rose-red: Trl.		Bkns; evolves water; *bor.* b.
C. bn; ywh-bn, yw, ywh-gy.		Exf. whitens; *bor.* fus.
C. w; gy, rh, gnh, ywh; dark-bn, bk: Trp—sbtrl.	Effervesce!	W: Intense light: Infus.
C. w; rh, bh, gyh: Trp—trl: Cleavages rectangnlar, distinct.	Not ef.	Evolves no moisture; Wh'ns, not exf; fus dif.
C. w, bh, rh, flesh-red: Trp—sbtrl.	Not ef.	Dec; fus.
C. w, ywh, gyh, bh, bnh, rh: Trp—sbtrl.	Not ef.	Dec; fus. dif!
C. leek-gn, bkh-gn, oily-gn, gyh, bh, rdh; none bright; ywh-gy, gyh-w, on exposure: Trl—op: Sect: Feel often soapy.		Hardens; fus. dif!
C. snow-w: Trl.		
C. pale yw; bnh, bnh-r: Sbtrp—trl.	Sol! in hot *nit.*	Fus; on ch. arsen., lead.
C. gnh-, gyh-w: Trl: Surface smooth.		W; infus.
C. w; gyh, ywh: Trp—trl.	Ef. *nit.*	Infus.
C. w, gyh, bnh: St. w, gyh: Trp—trl. Brittle.	Sol. ef. *nit.*	Dec. yw, r; met-lead.
C. ywh-w, orange-yw, gyh: Sbtrl—trl: Very brittle.	Ef. *nit.*	Fus. op. glob.
C. gyh-w, ywh: Trl: Lam. slightly elast.	Ef.	
C. and St. w.		
C. rose-red; bnh: Trl—sbtrl.	Ef. *nit.*	Bn. or bk; dec; infus: *Bor.* violet-b. glass.
C. light-gn, pale ywh-bn, yw, gy, w: St. w: Trp—trl.	Ef. *mur.* and *nit.*	Fus. on edges; color of flame rdh.
C. ywh-gy.	Pulv. ef. *nit.*	*Bor.* ywh-gn. or bn. glass
C. ywh-, ash-, gnh-gy; rdh: Darkens on exposure: Sbtrl.	Pulv. ef. *nit.*	B'kns; mag; infus: *Bor.* gn.
C. w, gnh, bh, ywh, bnh: Trl.	Sol. hot *nit*; evol. vap's corro. glass.	Infus. op.

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intense light under the blowpipe, and their amorphous and finely or impalpably granular structure, without a greasy feel.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
Stilbite, 304. *Amyg., prim.*	3·5—4	2·1—2·2	II : Rad, div, sheaf-aggreg, glob; particles lam. or fib.	Vit; . . p'rly.
•Heulandite, 303. *Amyg.,* [*prim.*	"	2·15-2·25	IV. Glob . mas.	P'rly ! & vit.
Laumonite, 317. *Amyg. & prim.*	"	2·25-2·35	IV: Mas.	Vit . . p'rly.
Schiller Spar, 299. *Serp.*	"	2·6—2·7	V, fol: Lam, gran.	Met-p'rly,vit.
Dolomite, 182.	"	2·8—2·9	VI, cleav: Imit; mas.	Vit; . . p'rly.
Ankerite, 183.	"	2·9—3·2	VI: Mas.	Vit . . p'rly.
Arragonite, 181.	"	2·6—3	III. Col, fib, imit.	Vit . . res.
Scorodite, 219.	"	3·1—3·3	III. Mas.	Ad . . vit.
•Hedyphane, 239. *Prim.*	"	5·4—5·5	VI: Mas.	Ad . . res.
*Huraulite, 216. *Gran.*	above 3	2·27	IV.	Vit.
•Levyne, 324. *Trap.*	4	2·198	VI.	Vit.
•Killinite, 286. *Prim.*	"	2·6 – 2·8	Cryst: cleav. mas.	Vit; weak.
Fluor Spar, 168.	"	3·1—3·2	I, cleav !: Mas.	Vit.
Barytocalcite, 190.	"	3·6—3·7	IV: Mas.	Vit . . res.
*Flucerine, 195. *Prim.*	"	4·7	VI: Mas.	Weak.
*Margarite, 296. *Prim.*	3·4—4·5	3—3·1	VI, fol ! gran.	P'rly, vit.
Bismuth Blende,206. *Prim.*	"	5·9—6·1	I: Glob, col, mas.	Res . . ad.
Chabazite,323 *Amyg., prim.*	4—4·5	2—2·1	VI: Ren, col, mas.	Vit ; . . ad.
*Gmelinite, 325. *Amyg.*	"	2—2·1	VI.	Vit.
*Phillipsite,319. *Prim, volc.*	"	2—2·2	III: Sheaf-aggreg; rad.	Vit.
*Harmotome, 318. *Amyg., &c.*	"	2·3—2·4	III: rarely mas.	Vit.
*Epistilbite, 312. *Amyg., volc.*	"	2·2—2·3	III, cleav: Mas.	Pearly . . vit.
*Carphosiderite, 225.	"	2·5	Reniform masses.	Res.
*Edingtonite, 306. *Amyg.*	"	2·7—2·8	II; hemihedral minute.	Vitreous.
*Pyrosmalite, 226. *Prim.*	"	3—3·1	VI. Hexag: Mas.	Pearly.
Rhomb Spar, 185.	"	3—3·15	VI, cleav; mas.	Vit; . . p'rly.
Tungst. of Lime,202. *Prim.*	"	6—6·1	II: Ren, col, mas.	Vit; . . ad.
Plumbo-resinite, 240. *Lead ores.*	"	6·3—6·4	Reniform.	Res.
*Amphodelite, 350. *Prim.* [*limestone.*	4·5	2·7—2·8	V: cleav. mas.	Vit . . p'rly.
•Herschellite, 342. *Trap.*	4—5	2·11	VI. hexag, cleav; often [aggreg.	
Tabular Spar, 359.	"	2·7—2·9	V: fib, lam.	Vit . . p'rly.
•Osmelite, 292. *Trachyte.*	"	2·7—2·9	Fib, stel, scopiform.	P'rly . . vit; weak.
Seybertite, 301.	"	3—3·1	Lam.	Met-pearly.
•Bronzite, 300.	"	3·2—3·3	V, fol !: Lam !	P'rly,met-p'r.
Apophyllite, 316. *Volc. &c.*	4·5—5	2·3—2·4	II, fol: Lam.	P'rly and vit.
•Dysclasite, 311. *Amyg.*	"	2·3—2·4	Fib.	Somewhat p'rly.
*Turnerite, 372. *Prim.*	"		IV, Cryst. small.	Subad.splend
*Pectolite, 327. *Amyg.*	"	2·69	Glob, div. fibres.	Vit . . p'rly.
Apatite, 169.	"	3—3·3	VI. Hexag: Col. mas.	Vit . . res.
Electric Celamine, 208.	"	3—3·5	III: Fib, bot, mas.	Vit . . p'rly,ad
•Yttrocerite, 200. *Prim.*	"	3·4—3·5	III, cleav: Mas.	Vit, p'rly.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. w; yw, r, bn: St. w: Sbtrp—trl.	Gel. in *nit*. dif!!	Intum; fus.
C. w, r, gyh, bnh: Sbtrp—trl.	Not gel. in *nit*.	Slight intum; fus.
C. w; ywh, gyh: St. w: Trl: Becomes op, white, and friable, on exposure.	Gelat.	Fus. w. frothy mass.
C. olive-gn, bkh-gn, pinchbeck-bn: St. gyh-w . . ywh: Sbtrl. Lam. separable.		Darker bn, more met.
C. w; rdh, gnh, gy, bn, bk: Subtrp—trl.	Ef.	
C. w; gyh, rdh, bnh: St. w—bn: Trl—sbtrl: darkens on exposure.	Some ef.	B'kns, infus. mag.
C. w, gy, yw, gnh, bh: St. gyh.w: Trp—trl.	Ef. *nit*. and *mur*.	Infus: Decrep; phosph. on red hot iron.
C. leek-gn, gnh-w; bh-w, liver-bn: Sbtrp—sbtrl.		Fus. rdh-bn. scoria; arsen.
C. w, gyh-w: Trl.		W. friable mass: Flame gnh-b; on char. arsen.
C. rdh-yw: Trp.		Fus! bk, met. button.
C. w; rdh: Sbtrp—op.	No action.	Intum. whitens.
C. gnh-gy, bn: St. ywh-w: Trl—sbtrl.	[glass.	Whitens; fus. w. enam.
C. w, yw, b, gn, r, often lively: Trp—trl.	*Sul*. fumes, corro.	Dec; phos! fus. dif.
C. w; gyh, ywh, gnh: Trp—trl.	Ef. in *nit*. or *mur*.	Infus; *Bor*. fus.
C. dark tile-r, ywh; deeper when wet: Sbtrl—op.		Inf: *Bor*. fus. dif; blood-r in outer flame while hot.
C. pearl-gy, rdh-w, ywh-w: Trl—sbtrl: Occurs in chlorite.		
C. dark hair-brown, ywh-gy, Straw-yw: St. ywh-gy.		Fus. dark yw; w. fumes.
C. w, rdh-w, ywh-w: Sbtrp—trl.	No action.	Fus. spongy glass.
C. w; flesh-r: Trp—trl: Very brittle.		Exf. in candle, and flies off in small scales.
C. w; rdh: Trp—op.		
C. w; gy, yw, rh, bnh: Sbtrp—trl: Cryst. often crossed.	Hot acid acts slowly.	Phos, yw. light; on ch. fus, no intum.
C. w: Trp—sbtrl.	Sol. strong *mur;* exc't sil.	Froths, vesic. enam. [fus! bk.
C. straw-yw: St. glimmering: Feel greasy.		Bk; fus. dif. mag: *Bor*.
C. gyh-w: Sbtrp—trl.		W, op; fus. dif. trp. glass
C. pale liver-bn, gy, gn, gnh-w: St. paler.	Sol. *mur;* exc't. sil.	Reddish-bn; mur. fumes; fus. dif.
C. w,gy; ywh,bnh; bn. on expos: Trp—trl.	Ef.	Bnh-bk: Inf.
C. w, ywh, bnh, orange-yw: Sbtrp—op.	Yw. in *nit;* not sol	Dec: Fus. dif!!
C. ywh, rh-bn, ywh-w; striped: Trl: Resembles gum arabic.		Dec; evolves water; inf.
C. light-r: Odor argil: Fr. like scapolite.		
C. w: Trl—op: Cleavage perf. par. with P.	[to powder.	
C. w, gyh-w, ywh, rh, bnh: Sbtrp—trl.	Ef! *nit*, then falls	Fus. dif!! *Bor*. fus! trp.
C. gyh-w, smoke-gy, hair bn. on exposure: Odor argil.	[*mur*.	Infus. *Bor*. trp. pearl.
C. rdh-bn: Sbtrl: Foliated struct. distinct.	Acted on by *nit*. &	
C. dark-gn, liver and pinchbeck-bn, ash-gy: Trp—sbtrl. Lam. easily separable.		Inf.; lighter color.
C. w, gyh, bh, gnh, rh: Trp—op.	*Nit*. subgelat.	Exf. int. fus. w; *Bor*. fus!
C. w, ywh, bh: Sbtrp—sbtrl: Very tough.	*Mur*. gel!	Op; fus. dif!! *Bor*. trp. glass.
C. yw; bnh: Trp—trl.		
C. w; ywh, gyh: Op. Resembles mesotype.		Fus. trp. glass.
C. sea-gn, bh, wh, gy, rh, bn; none bright: Trp—op: Brittle.	*Nit*. sol. slowly; not ef.	Fus. dif!! *Bor*. fus!
C. w; b, gn, yw, bn: Trp—trl.	Gel. in hot *nit*. [yw	Op, int, phos; inf: *Bor*, fus
C. violet-b, gy, w, rdh-bn: Op.	Pulv. sol. hot *nit*.	W, inf: *Gypsum* w. bead.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
Natrolite, 307. *Volc., amyg.*	4·5—5·5	2·1—2·3	III: Stel, rad, mas.	Vitreous.
Poohnahlite, 329.	"		III. Slender prisms.	Vitreous.
•Carpholite, 310. *Gran.*	"	2·9—3	Fib, rad, stel.	Silky.
•Thomsonite, 305. *Amyg.*	5	2·3—2·4	III cl: fib, rad, mas.	Vit.. p'rly.
•Alum Stone, 166. *Volc.*	"	2·694	IV: Mas.	Vit.. pearly; earthy.
Childrenite, 172.	4·5—5·5		III.	Vit.. res.
Humboldtilite, 557. *Volc.*	5	3·1—3·2		Vit.
•Herderite, 171. *Prim.*	"	2·9—3	III.	Vit.. res.
•Glaucolite, 352. *Prim.*	"	2·7—2·9	Mas. in perf. cleav.	Vit.
•Triphyline, 221. *Prim.*	"	3·6	III, cleav: Mas.	Vit.. greasy.
Calamine, 207.	"	4·2—4·5	VI: Bot; ren; mas.	Vit.. pearly.
Analcime, 320. *Amyg., volc. prim.*	5—5·5	2—2·1	I: Gran, Mas.	Vit.
•Brewsterite, 313. *Amyg,*	"	2·1—2·45	IV, Cleav.	Vit, pearly.
Mesotype, 308. *Amyg., volc.*	"	2·2—2·3	III: Stel. div. mas.	Vit.
•Scolecite, 309. *Volc. amyg.*	"	"	III: Div; Rad; mas.	Vit.. pearly.
•Comptonite, 315. *Volc., amyg.*	"	2·3—2·4	III: Coatings; Mas.	Vit.
Datholite, 326. *Amyg., prim.*	"	2·9—3	IV: Fib. Bot. mas.	Vitreous.
Anthophyllite, 365. *Prim.*	"	2·9—3·2	V, Cl: Col, fib-mas; Lam.	Pearly.
•Wagnerite, 170.	"	3—3·2	IV.	Vit.
Sphene, 415. *Prim.*	"	3·2—3·5	IV: Lam, Mas.	Ad.. resin.
Triplite, 214. *Granite.*	"	3·4—3·8	Lam, Mas.	Res.. ad.
•Willemite, 209. *Calamine.*	"	4—4·1	VI: Ren; Mas.	Resinous.
•Microlite, 199. *Granite.*	"	4·75—5	I, minute octahedrons.	Resin. [res.
•Yttro-Columbite, 433 *Prim*	"	5·3—5·4	Lam; grains.	Submet; vit,
Troostite, 357. *Prim.*	5·5	4—4·1	VI: Mas.	Vit; .. res.
•Cerite, 421. *Prim.*	"	4·8—5	Mas, vi.	Ad.
Scapolite, 351. *Prim.*	5—6	2·6—2·8	II: Col; lam; mas.	Vit; p'rly.
Boltonite, 552. *Prim. limest.*	"	2·8—2·9	Cleav, mas; gran.	Vit.
Hornblende,[†] 364. *Prim., volc.*	"	2·9—3·2	IV: Rad, col, fib, mas.	Vit.. p'rly.
Lazulite, 337.	"	3—3·1	III: Mas. [fib.	Vit.
Pyroxene, 361. *Prim., volc., basalt.*	"	3·2—3·4	IV, coarse cleav. mas,	Vit.. res, p'rly
•Arfwedsonite, 367. *Prim.*	"	3·3—3·5	IV, Cleav!	Vit, splend'nt
•Sodalite, 321.	5·5—6	2·2—2·4	I: Mas.	
•Leucite, 322. *Volc.*	"	2·4—2·5	I, Trapezohedrons; Mas.	Vit. not strong
•Nepheline, 340. *Volc.*	"	2·4—2·6	VI, hexagonal.	Vit.. p'rly.
•Elæolite, 343. *Prim.*	"	2·5—2·7	Imperf. crystalline, iii.	Res.
•Gehlenite, 353. *Prim. limest.*	"	2·9—3·1	II.	
Anhyd. Scolecite, 549. *Scap.*	5—6		Cryst.	Vit.

[†] This species occurs in fibrous forms, of apparent low degrees of hardness; occasionally they have the very peculiar structure (in the mineral kingdom) of cotton, or fibres of flax. Their action under the blowpipe, and the non-action of acids, in connection with their peculiar flexibility and loose aggregation, will dis-

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. w; ywh, gyh: St. gy: Trp—trl.	Gel! also after being heated.	Op; fus. glass.
C. w: Trp—trl.		
C. straw-yw, wax-yw: Op: Very brittle.		Intum, fus. dif; *Bor.* trp. violet.
C. w, bnh: Trp—trl: Brittle.		Swells up, snow w, op. fus. dif!!
C. w; rh, gyh: Trp—sbtrl.	Sol. *Sul.*	Dec. Inf. pulv.
C. y, pale ywh-bn, ywh-w: St. w: Trl.		
C. y, ywh-gy: Sbtrp.	Gelat.	Fus! spongy, trp. glass.
C. ywh-, gnh-w: Trl: Very brittle.		
C. lavender-b; gnh: Sbtrl.		Fus. dif!! *Bor.* fus.
C. gnh-gy, bh: St. gyh-w: Trl—sbtrl.	Soluble.	Fus! [zinc.
C. w, gyh, gnh, bnh, gn, bn: Sbtrp—trl.	*Nit.* ef., not gel.	Op. Inf; w. flocks oxyd.
C. w; rdh, gyh: Trp—op: Brittle.	Gel. *mur.*	On ch. fus. intum, glassy globule.
C. w; ywh—gyh: Trp—trl.		Op. froths; fus. dif.
C. w; gyh, ywh, rdh: Trp—trl.		Op; fus. glass: *Bor.* fus. dif.
C. w: Trp—trl.	Gel! *nit.* and *mur.* before, but not after ignition.	Op, and curls! in outer flame: Fus.
C. w: Sbtrp—trl.	Pul. gel. *nit.* and *mur.*	Intum, op, fus, vesic. glass.
C. w; gnh, ywh, gyh, rdh: Trl—sbtrl.	Gel! nit.	Friable in candle.
C. ywh-gy, bnh-gn, clove-bn: Trl—sbtrl.		Fus. dif!! *Bor.* fus. dif; grass-gn.
C. orange-yw; gyh: Trl.	Hot *Sul.* evolves Fluoric acid.	Fus. dif. dark gnh-gy. glass. *Bor.* fus. easily.
C. bn, yw, gy, gn; not lively: Sbtrp—op.	*Nit.* sol. exc't sil.	Yw: Fus. dif!!
C. bkh-bn: St. ywh-gy.	Nit, sol; no ef.	Fus! bk. scoria.
C. w; ywh, rdh-bn: Trp—op. [w—bn.	*Mur.* gel.	Flame gn; inf: *Bor.* fus.
C. straw-yw, dark rdh-bn: Trp—sbtrl: St.	Insol.	Unaltered.
C. bk, bn, yw, gnh: St. gyh-w.		Infus; dec. lighter color'd
C. pale gn, yw, gy, rdh-bn; none bright: Trp—trl.	Ef. *mur*; odor chlorine.	Trp; fus. dif!!
C. clove-bn . . cherry-r; gyh: Sbtrp—op: Brittle.		Infus: *Bor.* orange-yw. while hot.
C. w; gyh-bk, gnh, rh: Trp—sbtrl.		Int.; fus. dif. vesic. glass.
C. bh-gy, ywh-gy, gyh-w, often yw. on exposure		Infus; w, trp: *Bor.* trp. glass.
C. gn. of various shades of w, bn, bk, and intermediate shades: Sbtrp—op.		Fus. dif; glob. not clear. *Bor.* fus.
C. pure blue, gnh-b: St. w: Sbtrp—op.		Infus. *Bor.* clear globule.
C. gn, bnh, gyh, wh, bkh: Trp—op.		Fus. glassy globule.
C. bk: Op. [Trp—sbtrl.		Fus! opaque globule.
C. gyh-bk, ash-gy, gnh, deep azure-b, w:	*Nit.* gel.	Fus. dif. glass.
C. w, ywh, gyh; gy: Sbtrp—trl.	Powder greens the blue of violets.	Inf: *Bor.* fus. dif.
C. w, ywh: Trp—op.	*Nit*, nebulous; gel.	Fus. dif!!
C. dark-gn, bh-gy, bnh, brick-r: Trl.	Pulv. gel!	Fus. w. enamel.
C. gy; gyh, ywh; not bright: Op—sbtrl.	Heated *mur.* gel.	Fus. dif! *Bor.* slowly.
C. w: Trl.		Fus. dif; curls up.

tinguish these individuals from other species. They may, however, be confounded with pyroxene, or picrosmine, to distinguish which may require close examination and comparisons, with full descriptions.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
•Blue Spar, 338. *Prim.*	5·5—6	3—3·1	Massive, v.	Vit . . p'rly.
•Thulite, 422. *Prim.*	"	3·1—3·2	IV : Gran.	Vitreous.
•Acmite, 370. *Prim.*	"	3·2—3·4	IV, long pointed cryst.	Vit . . res.
Saussurite, 334.	"	"	Massive, cleav.	P'rly . . vit,res
•Babingtonite, 363. *Granite*	"	3·4—3·5	V.	Vit. splend.
•Anatase, 416. *Prim.*	"	3·8—3·9	II.	Met.-ad; res.
Feldspar, 345. *Prim.*	6	2·35—2·6	IV, cleav: Mas. [mas.	P'rly; vit.
•Pericline, 346. *Prim.*	"	2·5—2·6	V, Twin cryst., tabular;	Vit; p'rly.
Albite, 347. *Prim.*	"	2·6—2·7	V, cleav: Lam, gran.	P'rly, vit.
•Anorthite, 348. *Volc.*	"	2·65—2·8	V : Coarse col., lam.	P'rly . . vit.
Labradorite, 344. *Prim.*	"	"	V, cleav : Mas.	P'rly . . vit.
•Eudialyte, 410. *Prim.*	"	2·85-2·95	VI, cleav : Mas.	Vitreous.
•Turquois, 336.	"	2·8—3	Reniform ; no cleav.	Waxy, dull.
•Amblygonite, 371. *Granite*	"	3—3·1	IV : Columnar.	Vit. and p'rly
•Withamite, 369. *Trap.*	"	3·1—3·3	IV.	Vit.
Hypersthene, 302. *Prim.*	"	3·3—3·4	IV, cleav: Mas.	Met-pearly, bright.
•Hetepozite, 215.	about 6.	3·35-3·55	IV : Mas.	Res.
Opal, 398.	5·5—6·5	2—2·3	Mas, imitative.	Vit . . res.
•Erlamite, 555.	"	3—3·1	Mas, gran.	Greasy.
Brucite, 405. *Prim. limest.*	"	3·1—3·2	IV : Gran. mas.	Vit, res.
•Latrobite, 349. *Prim.*	"	2·7—2·8	V.	
Manganese Spar, 356. *Prim*	5·5—7	3·4—3·7	V : Mas.	Vit.
•Zurlite, 574. *Vesuv. limest.*	6 ?	3·2—3·3	Cryst. large and distinct.	Res.
•Gismondine, 354. *Volc.*	6—6·5	2·1—2·2	II.	Ad.
Petalite, 335.	"	2·4—2·5	Cleav. mas,—col, gran.	Vit . . resin, p'rly.
•Isopyre, 401. *Prim., basalt.*	"	2·7—3·7	Mas ; resembles obsidian.	Vit.
•Bustamite, 358.	"	3·1—3·3	Rad, lam, ren, bot, mas.	
Cummingtonite, 366. *Prim.*	"	"	Thin col, div, stel.	Pearly.
•Helvine, 404. *Prim.*	"	"	I, Cryst. hemihed.	Vit . . res.
•Diaspore, 376. *Prim.*	"	3·4—5	V, cleav : Lam. prisms.	Vit ; pearly, splend.
•Ligurite, 393. *Talc. rock.*		3·45—3·5	IV.	Vit. res.
•Bucklandite, 362. *Prim.*		3·9—4	IV, Less than 1 in. long.	Vit.
Kyanite, 374. *Prim.*	5—7	3·5—3·7	IV ; coarse col.	P'rly ; vit.
•Davidsonite, 554. *Granite.*	6·5	2·3—2·4	IV, cleav ; Mas.	
Idocrase, 407. *Volc., prim.*	"	3·3—3·45	II ; Mas.	Vit ; . . res.
•Obsidian, 399. *Volc.*	6—7	2·2—2·4	Mas.	Vit; p'rly; res
Prehnite, 332. *Amyg., prim.*	"	2·8—3	III : Bot, Mas.	Vit.
•Mellilite, 355. *Volc.*	"	3—3·3	II.	

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. smalt-b; wh, gnh: Sbtrl—op.		Loses color; inf.
C. rose-red: St. gyh-w: Trl—sbtrl. Grains easily separable.		*Soda* trp. uncol. globule.
C. bn, rdh-bn, bkh-gn: St. pale gnh-, or ywh-gy: Op.	No action.	Fus! bk. globule.
C. w; . . mountain-gn, gnh-gy, ash-gy.		Fus. dif! white glass.
C. dark gyh-bk, bnh: Sbtrl—op.		Bk. enamel; ***Bor.*** violet.
C. bn, indigo-b: Sbtrp—trl.		Loses col; infus. ***Bor.*** fus. dif.
C. wh, gy, gnh, bh, rh, r: Trp—sbtrl.	No action.	Fus. dif!! ***Bor.*** trp.glass.
C. w; ywh, rh.	No action.	Fus. dif! Sbtrp. glass.
C. w; gyh, rh, gnh, bh: Trp—sbtrl.	No action.	On ch. glassy; fus. dif!!
C. w: Trp—trl. Crystals never twins.	Strong ***mur.*** decomp.	Fus. dif!!
C. gy, bn, rdh-bn, gnh; play of colors b. and gn. Sbtrl.	Hot. ***mur.*** decom.	Fus. dif!!
C. bnh-r, rose-r: Op—sbtrl.		Fus. leek-gn. scoria.
C. bh-gn: Sbtrp—op.	No action.	Colors flame gn. ***Bor.*** fus!
C. pale mountain-, sea-gn: Sbtrp—trl.		On char. fus! trp; op. on cooling.
C. carmine-r. pale straw-yw. in certain directions by transmitted light.		Int.; fus. dif. bnh-gray scoria.
C. gyh-, bnh-bk, copper-r: St. gnh-gy: Sbtrl—op.		Inf.on char.gnh-gy.globule. ***Bor.***fus! gn. glass.
C. gnh-gy, bh: violet after exposure, and lustre submetallic.	Sol. exc't Silica.	Fus. submet. globule.
C. w, yw, r, bn, gn, gy; pale; play of colors in some specimens: Trp—sbtrl.		Dec., opaque; infus.
C. light gnh-gy: Sbtrl.		Fus! clear gnh. glass.
C. yw, bn, r; apple-gn: St. w; ywh: Trp—sbtrl.		Fus. dif! ***Bor.*** fus! ywh-gn.
C. pale red.		Fus. w. enamel. ***Bor.*** pale amethyst in oxydating flame.
C. flesh-r, bnh, gnh, ywh: Trp—sbtrl: Bn. on exposure.		Dark bn; fus. bkh. glass.
C. asparagus-gn: St. pearl-gy: Surface cryst. rough.	Sol.partly,*nit.*yw.	Inf. ***Bor.*** bh. glass.
C. pale smalt-blue, milk-w, gyh, rdh: Trl—sbtrp.		Phos, friable; inf.
C. w—bh, rh, gnh: Trl: Brittle.		Gentle heat blue phos; on char. glassy, inf; ***Bor.*** trp. glass.
C. gyh-, velvet-bk; often spotted red: St. light gnh-gy: Acts slightly on the magnetic needle.		Fus. without efferv.
C. light-gy; gnh, rh: Sbtrl—op.		
C. ash-gy: Trl—op: Fibres rather incoherent.		Fus. dif!! *Soda* ef. bk. glass.
C. wax-yw, ywh-bn, siskin-gn: Sbtrl.		On char. fus. with eff.
C. gnh-gy, hair-bn: Sbtrl—trl.		Decrep. violently.
C. apple-gn; sometimes speckled: Trp—trl.		
C. dark-bn, nearly bk: Op.	Sol. ***mur.***	
C. b—w. central line of crystals often blue, and the edges w: Trp—sbtrl.		Iufus. ***Bor.*** fus. dif. trp.
C. gnh-yw: Trl: Frangible.		Infus. ***Bor.*** trp. glass.
C. deep. bn, leek-gn, olive-gn, colorless: Trp—sbtrl.		Fus! pale gn. glass.
C. bk, bn, gy, w, none bright: Trl—sbtrl.		Fus. vesic. glass.
C. leek-gn, bh, gyh, w: Trl—sbtrl: Tough.		Whitens; Inf. ***Bor.*** fus. dif.
C. yw, rdh, gnh: Op.		Fus. gnh. glass.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
Bucholzite, 378. *Prim.*	6·7	3·1—3·2	Columnar.	P'rly, glistn'g
Epidote, 368. *Prim.*	"	3·2—3·5	IV : Gran, mas.	Vit, p'rly.
Tin Ore, 420. *Prim.*	"	6·5—7·1	II : Mas.	Ad. res.
Spodumene, 360. *Prim.*	6·5—7	3·1—3·2	III : Coarse fol, gran.	Pearly.
*Humite, 406. *Vesuv.*	"	"	III.	Vit.
Axinite, 396. *Prim.*	"	3·2—3·3	V, Cryst. flat and acute.	Vit, splend.
*Chrysolite,392. *Volc., basalt.*	"	3·3—3·5	III : Glob. mas.	Vit.
*Tautolite, 394. *Volc. feld-spar.*	"	3·8—3·9	III.	Vit.
Nephrite, 333.	6·5—7·5	2·9—3·1	Massive.	Vit.
Andalusite,† 373. *Prim.*	"	2·9—3·2	III : Col., gran.	Vit ; . . p'rly.
Garnet, 408. *Prim., volc.*	"	3·5—4·3	I : Gran.	Vit ; res.
*Sphærulite, 400.	7	2·4—2·5	In small spher. aggreg.	P'rly . . res.
Quartz, 397.	"	2·6—2·8	VI : Mas.	Vit, res.
*Boracite, 402. *Gypsum.*	"	2·9—3	I, small crystals.	Vit . . ad.
Iolite, 395. *Prim.*	"	2·5—2·75	III : Mas.	Vit.
Sillimanite, 377. *Prim.*	7—7·5	3·35-3·45	V, cryst. long ; div.	Vit . . p'rly.
Staurotide, 411. *Prim.*	"	3·5—3·8	III.	Vit . . res.
Turmaline, 379. *Prim.*	7—8	3—3·1	VI : Col, mas.	Vit.
Euclase, 381. *Prim.*	7·5	2·9—3·1	IV.	Vit.
Zircon, 409. *Volc., prim. &c.*	"	4·5—4·8	II : Gran.	Subadamantine.
Beryl, 380. *Prim.*	7·5—8	2·6—2·8	VI : Coarse col, gran.	Vit, res.
*Sapphirine, 388.	"	3·4—3·5	In cleav. grains.	Vit, splend.
*Forsterite, 391. *Vesuvius.*	"		III, cleav.	Vit, splend.
*Ostranite, 412.	7—8	4·3—4·4	III.	Vit.
Topaz, 390. *Prim.*	7·5—8	3·4—3·6	III, cleav : Col ; mas.	Vit.
Automolite, 385. *Prim.*	"	4·2—4·3	I, octahedral.	Vit . . res.
Dysluite, 386. *Prim.*	"	4·5—4·6	I, octahedral.	Vit . . res.
Phenacite, 382. *Prim.*	8	2·9—3	VI, rhombohedral.	Vit.
Spinel,‡ 384. *Prim.*	"	3·5—3·6	I.	Vit.
Chrysoberyl, 383. *Prim.*	8·5	3·5—3·8	III.	Vit.
Sapphire, 387. *Prim.*	9	3·9—4	VI : Mas.	Vit— . . p'rly.
Diamond, 389.	10	3·4—3·6	I.	Vit, ad.

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† The variety chiastolite of this species has often a hardness as low as 5. For the peculiarities of this variety, see § 373.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. w, gy, ywh: Trl—sbtrl.		
C. dark gn, ywh-gn, bh, gy, bn, rdh.		Fus. dif!! *Bor.* dif. trp.
C. w, gy, yw, r, bn, bk: Sbtrp—op.		*Bor.* on char. met-tin. dif.
C. gyh-w, gyh-gn, gnh-w: Trl—sbtrl.		Op. intum. exf; fus. uncolored glass.
C. yw; w, rdh-bn: Trp—trl.		Op; inf: *Bor.* trp. glass.
C. clove-bn; . . plum-b, pearl-gy: Trp—sbtrl.		Fus! int, dark gn. glass.
C. grass-, olive-gn, ywh, bnh: Trp—trl.		Darkened; infus. *Bor.* trp. glass.
C. velvet-bk: Op.		Fus. bkh. scoria., mag: *Bor.* clear gn. glass.
C. leek-gn; bh, rdh, gyh, wh: Trl—sbtrl.		Whitens; inf: *Bor.* clear glass.
C. pearl-gy, flesh-r: Tough.		Infus. *Bor.* fus. dif. trp. glass.
C. r, bn, yw, w, gn, bk: Trp—trl.		Fus. without efferv. bk. globule.
C. bn, yw, gy.		Edges enamelled.
C. w, violet-b, rose-r, bn, gn, yw, r: Trp—op.		Infus: *Soda* fus! ef. trp. glass.
C. w, gyh, ywh, gnh: Sbtrp—trl.		Intum; fus. w, op. glass.
C. b, bnh, ywh, ywh-gy: Trp—trl.		Fus. dif!! b, trp. glass.
C. hair-bn, gyh: Trl—sbtrl: Brittle.		Infus. *Bor.* inf.
C. bnh-red, bnh-bk; dark and not bright: Sbtrp—op.		Infus.
C. bk, bn, gn, dark-b, r, w: Light colors transparent, dark opaque.		Op. Intum. Elect.by heat.
C. mountain-gn, b, w, always pale: Trp—sbtrp.		Intum. in strong heat.
C. r, bn, yw, gy, gn, w; none bright except some red tints: Trp—trl.		
C. gn; bh, yh; pale except emerald-gn: Trp—sbtrl.		Edges rounded. *Bor.* trp. glass.
C. pale sapphire-blue: Trp—sbtrl.		Infus. *Bor.* infus.
Colorless: Translucent.		
C. clove-bn: Very brittle.		
C. yw, gn, b, w; pale: Trl—sbtrl.		Infus. *Bor.* slowly trp. glass.
C. dirty-gn, bk, b: Sbtrl—op.		Infus. *Soda* imperfect fusion; if re-fused ox. zinc on charcoal.
C. ywh-bn, gyh-bn: Sbtrl—op.		Red while hot; *Bor.* dif! red.
Colorless; bright wine-yw, rdh: Trp—op.		Infus. *Bor.* trp. glass.
C. r, bh, gnh, yh, bn, bk: Trp—sbtrl.		Infus: *Bor.* fus. dif.
C. gn; grass-gn, olive-gn, ywh, gyh: Trp—trl.		Infus. *Bor.* fus. dif!
C. b, r, gn, yw, bn, gy, w: Trp—trl.		Infus. *Bor.* fus. dif.
C. w, b, r, y, gn, bn, gy, bk: Trp—trl—sbtrl.		

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‡ Crystals occasionally present low degrees of hardness, which do not manifest any decomposition externally.

ARRANGEMENT OF THE MINERAL SPECIES IN CLASS II., SECTION I., SUBSECTION A., ACCORDING TO THEIR SPECIFIC GRAVITIES.

Scarbroite,	1·4—1·5
Mellite,	1·6
Websterite,	1·5—2
Cotunnite,	1·8—1·9
Halloylite,	1·8—2·1
Hydroboracite,	1·9
Chabazite,	2—2·1
Gmelinite,	“
Analcime,	2—2·1
Kerolite,	2—2·2
Phillipsite,	“
Opal,	2—2·3
Chrysocolla,	2—2·4
Herschellite,	2·11
Gismondine,	2·1—2·2
Stilbite,	2
Natrolite,	2·1—2·3
Heulandite,	2·15—2·25
Levyne,	2·198
Brewsterite,	2·1—2·45
Oxalate of Lime,	2·1—2·5
Mesotype,	2·2—2·3
Scolecite,	“
Epistilbite,	“
Huraulite,	“
Gypsum,	2·2—2·4
Sodalite,	“
Obsidian,	“
Native Magnesia,	2·3—2·4
Laumonite,	“
Mesolite,	“
Wavellite,	2·3—2·4
Harmotome,	“
Apophyllite,	“
Dysclasite,	“
Thomsonite,	“
Comptonite,	“
Davidsonite,	“
Nemalite,	2·3—2·5
Feldspar,	2·3—2·6
Gibbsite,	2·4
Leucite,	2·4—2·5
Petalite,	“
Sphærulite,	“
Marmolite,	2·4—2·6
Nepheline,	“
Carphosiderite,	2·5
Serpentine,	2·5—2·6
Pericline,	“
Picrosmine,	2·5—2·7
Iolite,	2·5—2·75
Elæolite,	2·5—2·7
Calc Spar,	2·5—2·8
Fahlunite,	2·6—2·7
Schiller Spar,	“
Albite,	“
Alumstone,	2·69
Pectolite,	“
Killinite,	2·6—2·8
Quartz,	“
Scapolite,	“
Pharmacolite,	“
Beryl,	2·6—8·2
Labradorite,	2·65—2·8
Anorthite,	“
Talc,	2·7—2·8
Pinite,	“
Hopeite,	“
Edingtonite,	“
Amphodelite,	“
Tabular Spar,	2·7—2·9
Osmelite,	“
Glaucolite,	“
Isopyre,	2·7—3
Hydromagnesite,	2·8—2·81
Haidingerite,	2·8—2·9
Agalmatolite,	“
Dolomite,	“
Boltonite,	“
Common Mica,	2·8—3
Black Mica,	“
Anhydrite,	“
Eudialyte,	“
Turquois,	“
Prehnite,	“
Cryolite,	2·9—3
Carb. Lime and Soda,	“
Carpholite,	“
Herderite,	“
Datholite,	“
Boracite,	“
Phenacite,	“
Gehlenite,	2·9—3·1

Subsection B. *Streak* colored.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
•Wad, 444.	0·5	3·7	Ren, bot, coatings.	Dull, earthy.
*Copper Froth, 266. *Cop. ores.*	1—1·5	3—3·1	III; cleav : Ren, bot, col.	P'rly, vit.
•Red Antimony, 531. *Antimony ores.*	“	4—4·6	IV: Tufts, div.	Ad— . . met.
Tungstic Acid, 202. *Tungsten.*			Mas, pulv.	Earthy.
•Earthy Cobalt, 443.		2·24	Bot, earthy.	Subresinous.
•Nickel Green, 269. *White nickel.*			Capillary cryst; pulv.	
*Uranic Ochre, 271.			Massive, earthy.	
•Cupreous Manganese, 440.	1·5	3·1—3·3	Ren, bot, mas.	Res.
Plumbic Ochre, 251. *Lead ores, volc.*			Mas.	Dull.

Nephrite,	2·9—3·1	Hypersthene,	3·3—3·4	Dysluite,	4·5—4·6
Euclase,	"	Idocrase,	3·3—3·45	Zircon,	4·5—4·8
Anthophyllite,	2·9—3·2	Sillimanite,	3·35—3·45	Flucerine,	4·7
Ankerite,	"	Chrysolite,	3·3—3·5	Microlite,	4·75—5
Hornblende,	"	Electric Calamine,	"	Cerite,	4·8—5
Andalusite,	"	Arfwedsonite,	"	Yttro-Columbite,	5·3—5·4
Margarite,	3—3·1	Hetepozite,	3·35—3·55	Hedyphane,	5·4—5·5
Pyrosmalite,	"	Yttrocerite,	3·4—3·5	Horn Silver,	5·5—5·6
Seybertite,	"	Babingtonite,	"	White Antimony,	"
Lazulite,	"	Diaspore,	"	Molybdate of Lead,	5·7—5·8
Blue Spar,	"	Sapphirine,	"	Polysphærite,	5·89—6·1
Amblygonite,	"	Ligurite,	3·45—3·5	Bismuth Blende,	5·9—6·1
Erlanite,	"	Topaz,	3·4—3·6	Corneous Lead,	6—6·1
Turmaline,	"	Diamond,	"	Tungstate of Lime,	"
Rhomb Spar,	3—3·15	Manganese Spar,	3·4—3·7	White Lead,	6·1—6·5
Wagnerite,	3—3·2	Triplite,	3·4—3·8	Leadhillite,	6·2—6·3
Apatite,	3—3·3	Diallogite,	3·5—3·6	Anglesite,	6·25—6·3
Mellilite,	"	Spinel,	"	Plumbo-resinite,	6·3—6·4
Fluor Spar,	3·1—3·2	Kyanite,	"	Horn Quicksilver,	6·4—6·5
Thulite,	"	Chrysoberyl,	3·5—3·8	Mimetene,	"
Brucite,	"	Staurotide,	"	Tin Ore,	6·5—7·1
Bucholzite,	"	Garnet,	3·8—4·3	Vanadate of Lead,	6·6—6·7
Spodumene,	"	Triphyline,	3·6	Dyoxylite,	6·8—7
Humite,	"	Spathic Iron,	3·7—3·9	Cerasite,	7—7·1
Scorodite,	3·1—3·3	Junkerite,	3·8—3·85	Tungstate of Lead,	7·9—8·1
Withamite,	"	Tautolite,	3·8—3·9		
Bustamite,	"	Anatase,	"	*Species in this sub-section whose specific gravity has not been determined.*	
Cummingtonite,	"	Bucklandite,	3·9—4		
Helvine,	"	Sapphire,	"		
Bronzite,	3·2—3·3	Willemite,	4—4·1		
Axinite,	"	Troostite,	"	Chenocoprolite.	
Dreelite,	3·2—3·4	Witherite,	4·1—4·35	Arsenate of Iron.	
Pyroxene,	"	Automolite,	4·2—4·3	Turnerite.	
Acmite,	"	Calamine,	4·2—4·5	Poohnahlite.	
Saussurite,	"	Bismuth Ochre,	4·3—4·4	Anhydrous Scolecite.	
Sphene,	3·2—3·5	Ostranite,	"	Forsterite.	
Epidote,	"	Heavy Spar,	4·3—4·8	Childrenite.	

Subsection B. *Streak* colored.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. & St. bn, bk : Op : Fract. earthy : Soils. Feels light on account of its porosity.		
C. pale apple-gn, . . sky-b : St. paler : Trl—sbtrl.		Dec ! flame gn : blackens fus. steel-gy. pearl.
C. cherry-r : St. bnh-r : Sbtrl.	*Nit.* w. coating.	Fus ! on ch ; volatilized.
C. lemon-yw.		Greenish.
C. bh, bnh, bk : Op : Sectile.		*Bor.* blue.
C. apple-gn, gyh, w : St. gnh-w.		Darkens ; on ch. arsen.
C. sulphur-yw ; bnh, rdh ; gently heated orange-yw.	Efferv., yw. sol.	Green.
C. and St. bh-bk : Op.		Bn ; inf : *Bor.* violet and gn.
C. between sulphur- and lemon-yw : St. paler.		Fus ! reduced to met. lead.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
Black Copper, 551. *Copper ores.*			Mas, pulv. coatings.	Earthy.
*Melanochroite, 246.		5·75	III; cryst. tab: Mas.	Res; glim.
*Minium, 250. *Lead ores.*		4·6	Mas. pulv.	
*Hisingerite, 449. *Calc spar.*		3—3·1	Cleav. mas, gran.	
*Cobalt Bloom, 231.	1·5—2	2·9—3	IV, fol!: Stel. fib, coatings.	Pearly—ad. earthy.
Vivianite, 223.	"	2·6—2·7	IV, fol! imit, mas.	P'rly; met, vit.
*Orpiment, 537.	"	3·4—3·5	III, fol: Imit, mas.	P'rly—met . . res.
*Realgar, 536.	"	3·4—3·7	IV: Mas.	Res.
*Copper Mica, 265. *Cop. ores.*	2	2·5—2·6	VI, fol!: Mas.	P'rly . . vit, ad.
*Blue Copper, 501. *Gray-wacke.*	about 2	3·8—3·82	Spher, surf. cryst.	Res, weak.
Sulphur, 538. *Volc., &c.*	1·5—2·5	2—2·1	III: Mas.	Res.
*Liroconite, 260. *Cop. ores.*	2—2·5	2·9—3	III: Mas.	Vit, res.
*Uranite, 272.	"	3·1—3·2	II, fol!: Gran.	P'rly . . ad.
*Miargyrite, 532.	"	5·2—5·3	IV.	Submet . . ad.
*Light Red Silver, 534.	"	5·4—5·6	VI: Mas.	Ad.
Cinnabar, 535.	"	8—8·1	VI, cleav: Mas.	Ad . . met.
*Cronstedtite, 227.	2·5	3·3—3·4	VI, fol!: Col, ren, mas.	Vit.
*Dark Red Silver, 533.	"	5·7—5·9	VI: Mas.	Met-ad.
*Sordawalite, 567. *Prim.*	2·5—3		Mas.	Vit.
Cube Ore, 217.	"	3	I: Mas.	Subadamant.
*Aphanesite, 253.	"	4·1—4·2	IV: Div.	P'rly.
*Atacamite, 264. *Volc., &c.*	"	4·4—4·5	III, cleav: Mas, in grains.	Ad . . vit.
Cupreous Anglesite, 249. *Lead ores.*	"	5·3—5·5	IV, cleav.	Vit, ad.
*Vauquelinite, 247. *Lead ores.*	"		IV: Imit, mas.	Ad, faint.
*Melanochroite, 246. *Lead ores.*	"	5·7—5·8	III.	Res, glim.
*Chromate of Lead, 245.	"	6—6·1	IV. Columnar, mas.	Ad.
*Caledonite, 248. *Lead ores.*	"	6·4	III: Div.	Res.
*Pyrorthite, 426. *Granite.*	3	2·1—2·3	Long thin imbed. cryst.	Res, weak.
Olivenite, 263.	"	4·1—4·3	III. Col, div, fib, imit, mas.	Ad . . vit, and p'rly.
*Green Iron Ore, 228.	3—4	1·7—2	Mas, ren, earthy.	Res; dull.
*Cacoxenite, 222. *Brown iron ore.*	"	3·3—3·4	Div. fibres.	Silky.
*Pyrargillite, 279. *Granite.*	3—5	2·5	II: Mas.	Shining.
Ankerite, 183.	3·5—4	2·9—3·2	VI: Mas.	Vit . . p'rly.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. bk, bh: Friable; scarcely soils.	*Nit.* sol.	
C. hyacinth-r; orange-r; lemon-yw on exposure: St. brick-r: Sbtrl—op.		Fus. bn, cryst. on cooling.
C. aurora-red.		Fus. globule of lead.
C. bk: St. gnh-gy, bnh-yw: Cross fract. earthy.		Low heat, mag; higher fus. bk: *Bor.* ywh-gn.
C. crimson and peach-blossom-r—pearl-gy, gnh: St. paler: Dry powder deep lavender-b. Lam. flex.		Darkens; on char. arsen. *Bor.* fine blue.
C. pale bkh-gn—indigo-b: St. bh-w—b: Lam. flex. Powder of dry mineral crushed, liver-bn.		Dec; loses color; fus. dark bn. scoria, magnetic.
C. lemon-yw: St. paler: Sbtrp—sbtrl: Sect: Lam. flex.	Sol.	Fumes of sulph. and arsen.
C. bright aurora-r: St. orange-yw—r: Sectile.		On char, burns b. flame, alliaceous odor.
C. emerald-gn, grass-gn: St. paler: Trp—trl.		Op, arsen; fus. bk. glob.
C. indigo-b: St. lead-gy; shining: Sectile.		
C. and St. sulphur-yw, rdh, gnh: Trp—sbtrl.	No action.	Burns at low temp. b. flame.
C. sky-b—verdigris-gn: St. paler: Sbtrp—trl.	*Nit.* sol., no ef.	Loses color and trpncy; arsen.
C. emerald and grass-gn; apple-gn: St. paler: Trp—sbtrp: Lam. brit., not flex.	*Nit.* sol., no ef.	Op. yw; fus. bk. glob.
C. iron-bk: St. dark cherry-r: Sbtrl—op.	Dilute *nit.* sol.	Fumes of sulph. and antimony.
C. cochineal-r: St. cochineal-r—aurora-r: Sbtrp—sbtrl.		Fus. b. flame; sul. and arsen.
C. cochineal-r—bnh-r, lead-gy: St. scarlet-r, bnh: Sbtrp—sbtrl.	*Nit.* sol. r. fumes.	Wholly volatilized.
C bnh-bk: St. dark leek-gn: Op: Lam. elastic.	Pulv. gel! *mur.*	Froths a little, not fus.
C. iron-bk—lead-gy: St. cochineal-r: Sectile: Trl—op.		Dec; fus, bh, flame; sulph.
C. gyh-, bh-bk: Becomes rdh. on exposure: St. liver-bn: Op.	*Mur.* partly sol.	Fus. dif. bkh. globule: *Bor.* gn.
C. olive-gn, ywh-bn, bkh, grass-gn: St. pale olive-gn—bn: Sbtrl.		Low heat r; higher, int. r. powder: On ch. ars.
C. dark verdigris-gn—sky-b: St. verdigris-gn: Sbtrl.		Def. fus! arsenic. fumes.
C. olive-, grass-gn, bkh-gn: St. apple-gn: Trl—sbtrl.		Flame b. and gn; muriatic fumes.
C. fine azure-b; St. pale-b: Trl—sbtrl.		Indicates cop. and lead.
C. bkh-, olive-gn: St. siskin-gn; bnh: Trl—op.		Intum; fus. gyh. glob. containing lead.
C. between coch. and hyacinth-r; lemon-yw on exposure: St. brick-r: Sbtrl—op.		Fus! bn. cryst. on cooling.
C. hyacinth-r: St. orange-yw: Trl: Sect.	*Nit.* yw. sol, no ef.	Bkns; dec, fus. shining slag.
C. deep verdigris-, mountain-gn: St. gnh-w: Trl.		
C. and St. bnh-bk; ywh-bn, if weathered: Op.		Gently heated inflames; fus. bk. enamel.
C. gn, bn: St. olive-gn—bn: Sbtrp—op.	Sol. *nit.*	Unalt; on ch. fus. with defl., met. glob.
C. pistachio-gn, bkh, ywh: Op—Sbtrl.		Bn. and bk; infus.
C. ywh-bn: St. ywh.		
C. bkh: odor argillaceous when heated.	Sol. *nit.*	
C. w; gyh, rdh, bnh; darkens on exposure; St. bn: Trl—sbtrp.	Ef. slowly.	Bkns. mag. infus.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
*Brochantite, 267. *Cop. ores.*	3·5—4	3·7—3·8	III.	Vit.
Green Malachite, 255. *Cop. ores.*	"	4—4·1	IV: Fib, bot, mas, coatings.	Vit . . ad. silky, earthy.
Blende, 530.	"	4·6—4·9	I, cleav: Fib, mas.	Ad; res—submet.
Red Copper Ore, 418.	"	5·9—6	I: Fib, mas.	Ad. sub-met.
Pyromorphite, 241.		6·8—7·1	IV: Imit, mas.	Res.
Euchroite, 258. *Prim.*	3·5—4·25	3·3—3·4	III.	Vit.
Blue Malachite, 254.	"	3·8—3·9	IV: Bot, mas.	Vit, ad.
Bismuth Blende, 206.	"	5·9—6·1	I: Glob, col, mas.	Res, ad.
*Crocidolite, 448.	4	3·2—3·3	Fib; fibres separable, mas.	
Libethenite, 262.	"	3·6—3·8	III.	Res.
*Carphosiderite, 225.	4—4·5	2·5	Reniform, mas.	Res.
*Pyrosmalite, 226. *Prim.*	"	3—3·2	VI: Mas.	P'rly, vit.
*Herrerite, 270. *Silv. ores.*	"	4·3	Ren, 3 oblique cleav.	Vit, p'rly.
Red Zinc Ore, 413. *Prim.*	"	5·4—5·6	III, fol: Mas.	Subadamant.
*Bronzite, 300. *Prim.*	4—5	3·2—3·3	IV, fol!: Lam, mas.	Met-p'rly.
Flucerine, 195.	"	4·7	VI: Mas.	Vit.
*Beudantite, 550.	4—4·75		VI, cleav: Lam, mas.	Res.
*Xenotime, 201.	4·25—5	4·5—4·6	II, cleav.	Res.
*Erinite, 259. *Cop. ores.*	4·5—5	4—4·1	Imp. cryst; concentric [struct.	
Pseudo-Malachite, 261. *Cop. ores.*	"	4·1—4·3	III: Col, bot, mas.	Ad . . vit.
Orthite, 425. *Prim.*	5	3·2—3·3	Long. acic. crystals.	Vit.
*Dioptase, 257.	"	"	VI.	Vit, . . res.
Pyrochlore, 419. *Prim.*	"	4·2—4·3	I.	Res . . vit.
*Subsesquifluate of Cerium, 196.	"	4·7	I: Mas.	Vit.
Triplite, 214. *Prim.*	5—5·5	3·4—3·8	Mas, cleav.	Res . . ad.
Brown Iron Ore,† 451.	"	3·9—4·1	III: Bot, mas.	Ad; submet; earthy.
Hausmannite, 437.	"	4·7—4·8	II: Mas.	Submet.
Wolfram, 436. *Prim.*	"	7—7·4	III, cleav: Coarse col. lam.	Submet.
*Œrstedite, 430. *Prim.*	5·5	3·6—3·7	II.	Splend.
Chromic Iron, 447. *Serp.*	"	4·3—4·5	I: Mas.	Submet.
Pitchblende, 435.	"	6·4—6·5	Bot, mas.	Submet.
*Isopyre, 401. *Prim.*	5—6	2·9—3	Mas.	Vit.
Psilomelanite, 439.	"	4—4·4	Mas: Bot, mas.	Submet.
*Æschynite, 429. *Prim.*	"	5·1—5·6	IV: Mas.	Res.
*Monazite, 560.	5·5—6	4·8—5	IV.	Vit; weak.
*Brookite, 417.	"		III.	Met-ad.

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† For the various forms which this very varying species may present, refer to the full descriptions of the species, § 451. Specular iron often assumes a non-metallic

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. emerald-gn: Trp.		Blackens; infus.
C. gn: St. paler: Trl—op.	Ef. *nit.*	Bk. *Bor.* fus!
C. yw, bn, bk, gn, r; none bright: St. w, rh, bn.	Sol. *mur.*	High heat zinc fumes; infus.
C. cochineal-, carmine-r: St. bnh-r, Sbtrp—sbtrl. Often coated with gn. malachite.	Sol. ef. *nit*: Sol. *mur*, no ef.	On char. met. copper.
C. gn, bn; gy: St. yw: Sbtrp—sbtrl.	Sol. hot *nit*, no ef.	Fus. on ch. cryst. on cooling.
C. bright emerald-gn: St. pale apple-gn: Trp—trl.		At certain heat on ch. reduced with deflagration.
C. azure-b, bkh-b: St. paler: Trp—sbtrl.	Ef. *nit.*	Bk: Fus. on ch. *bor.* gn.
C. dark hair-bn; yw, gy; straw-yw: St. ywh-gy: Trp—op.		Dec; fus. glass.
C. and St. lavender-b, leek-gn. Fibres somewhat elastic.		Fus! bk. glass, shining.
C. dark olive-gn: St. olive-gn: Sbtrl.		First bnh. glob, then rdh-gy. met; lastly met. cop.
C. and St. straw-yw: St. glimmering: Feel greasy.		Bk: fus. dif. mag: *Bor.* fus.
C. pale liver-bn, gyh, gnh: St. paler: Trl—op.	*Nit.* sol., except silica.	Odorous fumes, rdh-bn; fus. bk. slag.
C. pistachio-, emerald-gn, grass-gn: St. ywh-gy: Trl.		On char. w. fumes: Fus. bk. glob.
C. r; ywh: St. orange-yw: Sbtrl—op.		Infus. *Bor.* yw. glass.
C. dirty leek-gn, bkh; bn, ash-gy: St. same.		
C. fine yw, rdh, bnh: Sbtrl—op: St. w, ywh.		Bkns, inf; *bor.* r. when hot, colorless on cool'g.
C. bk; dark bn: Trl—op: St. gnh-gy.		
C. ywh-bn: St. pale bn: Op.		Infus: *Bor*, milky glob. when cool.
C. emerald-gn, grass-gn: St. paler: Sbtrl.		
C. emerald-gn. bkh: St. paler: Trl—sbtrl.	Hot *nit.* sol. no ef.	Fus! vesic. submet.
C. bk . . ash-gy: St. bnh-gy.		Intum. ywh-bn; fus. ef. vesic. bk: *Bor.* fus!
C. emerald-gn, bkh: St. gn: Trp—trl.	Sol. *mur.* no ef.	Dec, ywh-gn flame. Inf.
C. rdh-bn: St. clear pale bn: sbtrl—op.		Ywh-bn; fus. dif! *Bor.* yw trp. glob. in ox. flame.
C. fine yw, rdh, bnh: St. fine yw: Sbtrl—op.	*Sul.* yw: Sol. *mur.* odorous! fumes.	B'kns inf: *Bor.* like flucerine.
C. bkh-bn: St. ywh-gy: Sbtrp—op.	Sol. *nit.* no ef.	Fus! bk scoria.
C. bn, ywh, bkh, not bright: St. ywh-bn: Sbtrp—op.	*Nit-mur.* sol.	Bk. mag; infus.
C. bnh-bk: St. chesnut-bn: Op.	Hot *mur.* odor!	Fus. in oxyd. flame amethyst globule.
C. dark gyh-, bnh-bk: St. dark rdh-bn: Op.		Dec; fus. dif. met. glob. cryst; *phos* deep r. glob.
C. brown.		
C. iron bk, bnh: St. bn: Infus.		*Bor* fine gn. glob.
C. gyh-bk, iron-bk, gnh, bnh, velvet-bk: St. bk: Op.		Infus: *Bor.* gy. scoria.
C. gyh-bk, velvet-bk: often spotted red: St. pale gnh-gy: Op—sbtrl.		Fus. without intum.
C. bk, dark steel-gy: St. rdh-, bnh-bk: Op.	*Mur.* sol; odor!	
C. bkh: bnh-yw: St. dark gy, nearly bk: Trl—op.		Swells; yw; *bor.* dark yw.
C. bn, smoky-r: St. rdh-w.		Inf: *Bor.* on ch. fus. yw. op.
C. hair-bn; orange yw, rdh; St. ywh-w: Trl—op.		

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lustre, a red color, argillaceous aspect, low hardness, and a fine granular or lenticular structure. See § 452.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Lustre.*
*Sodalite, 321. *Volc., &c.*	5·5—6	2·2—2·4	I: Mas.	Vit.
Yenite, 450. *Prim.*	"	3·8—4·1	III: Col; mas.	Submet.
*Fergusonite, 432. *Prim.*	"	5·8—5·9	II.	Fract. surf. vit, splend.
Brucite, 405. *Prim.*	5·5—6·5	3·1—3·3	IV: Gran, mas.	Vit; .. res.
Hypersthene, 302. *Prim.*	6	3·3—3·4	IV, fol!; mas.	Met-p'rly.
*Allanite, 423.	"	3·2—4·1	V: Acic; mas.	Submet; res.
*Acmite, 370. *Prim.*	6—6·5	3·2—3·3	IV, long pointed cryst.	Vit; .. res.
Rutile, 414. *Prim.*	"	4·2—4·3	II: Mas.	Ad—met-ad.
*Thorite, 424. *Prim.*	"	4·6—4·7	Massive.	Vit, res.
*Polymignite, 431. *Prim.*	6·5	4·7—4·9	III, usually thin and striated.	Submetallic; splendent.
Tin Ore, 420. *Prim.*	6—7	6·5—7·1	II: Div, fib; mas.	Ad.
*Gadolinite, 427. *Gran.*	6·5—7	4—4·3	IV: Mas.	Vit; res.
*Titaniferous Cerite, 428.	"			Vit.

ARRANGEMENT OF THE MINERAL SPECIES IN CLASS II., SECTION I., SUBSECTION B., ACCORDING TO THEIR SPECIFIC GRAVITIES.

Green Iron Ore,	1·7—2	Hisingerite,	3—3·1	Hypersthene,	3·3—3·4
Sulphur,	2—2·1	Pyrosmalite,	3—3·2	Orpiment,	3·4—3·5
Pyrorthite,	2·1—2·3	Uranite,	3·1—3·2	Realgar,	3·4—3·7
Cobaltic Manganese,	2·24	Cupreous Manga-		Triplite,	3·4—3·8
Sodalite,	2·2—2·4	nese,	3·1—3·3	Œrstedite,	3·6—3·7
Pyragillite,	2·5	Brucite,	"	Libethenite,	3·6—3·8
Carphosiderite,	"	Crocidolite,	3·2—3·3	Allanite,	3·2—4·1
Copper Mica,	2·5—2·6	Bronzite,	"	Wad,	3·7
Vivianite,	2·6—2·7	Orthite,	"	Brochantite,	3·7—3·8
Cobalt Bloom,	2·9—3	Dioptase,	"	Blue Copper Ore,	3·7—3·82
Liroconite,	"	Acmite,	"	Blue Malachite,	3·8—3·9
Isopyre,	"	Cronstedtite,	3·3—3·4	Yenite,	3·8—4·1
Cube Ore,	3	Cacoxenite,	"	Brown Iron Ore,	3·9—4·1
Copper Froth,	3—3·1	Euchroite,	"	Green Malachite,	4—4·1

SECTION II. LUSTRE METALLIC.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Streak.*
Native Mercury, 466.		13—14	Liquid.	
*Iodic Silver, 275.	Soft		Fol! mas.	Silver-w, submet.
*Flexible Silver Ore, 523.	1—1·5		IV, fol!; tab. mas.	Shining.
Molybdenite, 524. *Prim.*	"	4·5—4·8	VI, fol! fol-mas.	Lead-gy, gnh
*Sternbergite, 522. *Silver ores.*	"	4·1—4·3	III, fol! rose-like agg.	Black.
*Foliated Tellurium, 521.	"	7—7·1	II, fol! gran.	Bkh. lead-gy.
*Bitellurid of Lead, 521.	"	8·1—8·2		
*Auro-Tellurite, 464.	"	10—11	III: Small cryst. and [cryst. lam.	
Lead, 468. *Volc. & prim.*		11—12	I: Membranes and glob.	Shining.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. gyh-bk, ash-gy, bn, azure-b, gn, w: St. paler: Trp—trl.	Gel. *nit.*	Fus. dif. w. glass.
C. iron-bk, dark gyh-bk: St. bk, gnh, bnh: Op.	*Mur.* sol.	On char. bk. globule.
C. dark bnh-bk; bn. in thin scales and trl: St. pale brown: Op.		Gnh-yw; infus: *Bor.* fus. dif.
C. yw, gnh, bn, r—light: Trp—sbtrl.		Fus. dif!! loses col. op.
C. gyh-, bnh-, gnh-bk; copper-red: St. gnh-gy: Op—sbtrl.		Inf: On ch. gnh-gy op. glob. Sol. in *borax.*
C. bnh, gnh-bk: St. gnh-gy: Op—sbtrl.	Gel. *nit.*	Froths; black scoria.
C. bnh-bk, ywh, gnh: St. pale gnh-gy: Sbtrl—op.		Fus. bk. glob. mag.
C. rdh-bn, ywh: St. pale bn: Trl—op.		Inf: *Bor.* ywh-r. glass.
C. bk; bnh: St. dark bn; frangible.		Pale bnh-r; Infus: *Bor.* fus. iron-colored glob.
C. bk; op: St. dark bn. Fract. brilliant submet.		Unalt. *Bor.* fus! colored globule.
C. bn, bk, r, yw, gy, w: St. pale gyh-bn: Sbtrp—op.	Insol.	Infus: *Bor.* on char. reduced to metal.
C. gnh-bk, dark: St. gnh-gy: Sbtrl—op.	Gel. hot *nit.*	Dec: vivid glow; on ch. swells, gyh-gn.
C. bkh-bn.	Acted on by acids.	Swells.

Erinite,	4—4·1	Hausmannite,	4·7—4·8	Tin Ore,	6·5—7·1
Gadolinite,	4—4·3	Polymignite,	4·7—4·9	Pyromorphite,	6·8—7·1
Psilomelane,	4—4·4	Monazite,	4·8—5	Wolfram,	7—7·4
Aphanesite,	4·1—4·2	Æschynite,	5·1—5·6	Cinnabar,	8—8·1
Pseudo-Malachite,	4·1—4·3	Miargyrite,	5·2—5·3		
Pyrochlore,	4·2—4·3	Cupreous Anglesite,	5·3—5·5	*Species whose specific gravity has not been determined.*	
Rutile,	"				
Herrerite,	4·3	Light Red Silver,	5·4—5·6	Tungstic Ochre.	
Chromic Iron,	4·3—4·5	Red Zinc Ore,	"	Nickel Green.	
Atacamite,	4·4—4·5	Melanochroite,	5·75	Uranium Ochre.	
Red Antimony,	4·4—4·6	Dark Red Silver,	5·7—5·9	Plumbic Ochre.	
Xenotime,	4·5—4·6	Fergusonite,	5·8—5·9	Black Copper Ore.	
Minium,	4·6	Red Copper Ore,	5·9—6	Sordawalite.	
Thorite,	4·6—4·7	Bismuth Blende,	5·9—6·1	Vauquelinite.	
Blende,	4·6—4·9	Chromate of Lead,	6—6·1	Beudantite.	
Flucerine,	"	Caledonite,	6·4	Brookite.	
Subses'fl. of Cerium,	4·7	Pitchblende,	6·4—6·5	Titaniferous Cerite.	

SECTION II. LUSTRE METALLIC.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. tin white.		
C. w, ywh, gn; bk. specks of met. silver: Lam. flex.		Fus! on ch. flame violet, glob. of silver obtained.
C. (external) nearly bk: Lam. flex.		Yields sulph. and silver.
C. pure lead-gy: Sectile; lam, flex.	*Nit.* ef.	Infus; sulph. odor.
C. dark pinchbeck-bn; tarnish violet-b: Traces on paper: Lam. flex!		On ch. b. flame: Sulph.
C. blackish lead-gy: Lam, flex: Sectile.	Sol! *nit.*	On ch. fus! w. fumes, flame blue.
C. tin-white: Easily reduced to powder: Sectile.	Sol! *nit.*	On char. fus! flame b; fumes.
C. silver-w . . brass-yw; rather brittle.	Sol. *nit.*	Fus! pungent odor.
C. lead-gy: Malleable; Soils.	Sol. hot *nit.*	Fus!! volatile.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Streak.*
*Hisingerite, 449. *Calc spar.*	Soft	3—3·1	Cleav. mas; gran.	Gnh-gy; bnh-yw.
Graphite, 547.	1—2	2—2·1	Fol-mas; gran.	Bk, shining.
*Molybdic Silver, 511.	Soft	7·2—8	VI: Cleav. cryst.	Dark iron-bk
*Cobaltic Galena, 519. *Gray-wacke.*	"	8·4—8·5	Small grouped cryst: Mas.	
*Feather Ore of Lead, 515. *Quartz.*	"		Capillary crystals.	
*Graphic Tellurium, 507. *Gold.*	1·5—2	5·7—5·8	III: Acic; col; mas.	Pure steel-gy
*Gray Antimony, 512.	2	4·5—4·7	III, cleav: Div. col; fib; mas.	Lead-..steel-gy.
*Vitreous Silver, 505. *Prim.*	"	7·1—7·4	I: Capil; retic; mas.	Bkh. lead-gy.
*Telluric Bismuth, 527.	"	7·5—7·6	VI, fol!	
*Rionite, 528.	Soft	5·5—5·6		Bkh.
*Bismuth Silver, 470.	"		Acic; mas.	
Pyrolusite, 442.	2—2·5	4·8—5	III: Rad; col: Mas.	Bk. [red.
*Miargyrite, 532.	"	5·2—5·4	IV.	Dark cherry-
*Antimonial Sulphuret of Silver, 510.	"	5·5—5·6	III, cleav: Mas.	
*Jamesonite, 515.	"	5·5—5·8	III, cl. parallel with P; col. parallel or diverg.	Steel-gy.
*Native Tellurium, 472.	"	5·7—6·1	VI: Mas.	Tin-white.
*Acicular Bismuth, 526. *Prim.*	"	6·1—6·2	Acic; col; mas.	Bkh-gy.
*Brittle Silver Ore, 509.	"	6·2—6·3	III.	Iron-bk.
Sulphuret of Bismuth, 525.	"	6·5—6·6	III: Acic; fol; fib; mas.	Lead-gy.
*Arsenid of Copper, 492.	"	4·5	Mas. and disseminated.	
*Clausthalite, 520.	"	6·8—7·2	Mas; seldom col.	Dark-gy.
*Selenid of Lead &Cop.520	"		Mas.	
*Cinnabar, 535.	"	8—8·1	VI, cleav: Mas.	Red.
*Telluric Silver, 506. *Talcose rock.*	"	8·412	Coarse gran. masses.	Shining.
*Eucairite, 503.	"		Mas, thin films.	[nail, wh. Impressed by
Bismuth, 469. *Prim.*	"	9·7—9·8	I, cleav.	Silver-w . . r.
*Arsenical Antimony, 516.	2—3	6·2	Reniform masses.	
*Polybasite, 508.	"	6·2—6·3	VI: Tab. hexag: Mas.	Bk. splend.
*Varvacite, 445.	2·5	4·5—4·7	Cryst; fib. rad.	Bk.
*Dark Red Silver, 533.	"	5·7—5·9 "	VI: Gran, mas.	Cochineal-r.
Vitreous Copper, 500.	2·5—3	5·5—5·8	III. Mas.	Bkh. lead-gy.
*Bournonite, 498.	"	5·7—5·8	III. Mas.	Steel-gy—bk.
Galena, 518.	"	7·5—7·7	I, cleav! gran. mas.	Lead-gy.
Native Copper, 471.	"	8·5—8·6	I: Fib., mas.	Copper-red.
Native Silver, 465.	"	10—11	I: Capil., fib., mas.	Shining.
*Native Gold, 463.	"	12—20	I: Cap., mas.	
Capillary Pyrites, 495.	3?		Capillary cryst.	
Variegated Pyrites, 493.	3	6—6·1	I: Mas.	Pale gyh-bk.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. bk: Cross fract. unearthy: Lustre submet.		Mag; fus. dif.
C. iron-bk; dark steel-gy: Op: Sectile.	No action.	Inf.
C. pale steel-gy: Electric in thin laminæ.		
C. lead-gy . . b: Soils a little.		Fus. in candle; *bor.* b.
C. lead-gy: Lustre glistening submet: Sectile.		Fus! in candle; w. fumes.
C. pure steel-gy; very sectile.	*Nit.* sol.	On ch. fus! dark gy. met. glob; flame gnh-b.
C. lead-gy . . steel-gy; tarnish: Lam, subflex.	*Sul.* fetid odor.	Fus!! on ch. odor of sulphur.
C. bkh-, lead-gy: Malleable.	Sol. *nit.*	Intum, fus; glob. of silver.
C. pale-steel-gy—silver-w: Lam. elastic: Soils paper.	*Nit.* sol.	Fus!! vol! yw. on ch.
C. lead-gy—cochineal-r.		Burns, violet flame and odor of horse radish.
C. tin-w, gyh; tarnish: Sectile.		Fus! ox. lead & bismuth on char.
C. iron-bk—bh.	*Mur.* strong odor.	*Bor.* amethyst. glob.
C. iron-bk: Lus. met, met-ad: Op.		Fus; fumes sulph. & ant.
C. light steel-gy . . silver-w.		W. vapors, sulph; w. met. glob.
C. steel-gy: Sectile.		Fus! w. fumes, antim.
C. tin-w: Rather brittle.		Fus! on ch. gnh. flame, vol, w. fumes.
C. pale bkh- lead-gy; light copper-r. tarnish; ywh.		Fus! b. flame, sulph.
C. iron-bk: Sectile.	Dilute *nit.* sol.	Fus! sulph. and antim.
C. lead-gy: Sectile.	Hot *nit.* sol.	
C. between tin-w. and brass-yw: Fr. fine-grained: Easily frangible.		Arsen. fumes, fus. gyh-bk. slag.
C. lead-gy . . b; rather sectile.		Fus. Odor horse-radish, blue flame on char., rdh-bn.
C. lead-gy . . violet.		
C. lead-gy, bnh-r, cochineal-r: Sbtrp—op.	*Nit.*sol. red fumes	Volatile.
C. lead-gy . . steel-gy.		On char. fus. bk. mass: In glass tube, colors tube yellow. [on char.
C. silver-w . . lead-gy: Ductile.	Hot *nit.* sol.	Odor horse-radish; fus!
C. silver-w, inclined to r; subject to tarnish.	Sol. *nit.*; solution white if diluted.	Fus! vol. yw. on char.
C. tin-w, splendent—dull.		Fus! fumes ars. and ant.
C. iron-bk.		
C. iron-bk, steel-gy: Lustre submet.		
C. iron-bk—lead-gy; . . coch.-red: L. met-ad. Trl—op.		Dec. fus. b. flame, sulph. and antimony fumes.
C. bkh- lead-gy: St. sometimes shining: Sectile.	*Nit.* sol.	Fus. in oxyd. flame; sulph: Infus. in reducing flame.
C. steel-gy, bkh-lead-gy, iron-bk: Brittle.	*Nit.* sol.	Fumes arsenic or ant.
C. pure lead-gy: Rather sectile.		Dec. fus. Sulph. odor. finally on char. glob. Lead.
C. copper-red: Ductile: Malleable.	Sol! *nit.* r. fumes.	Fus.
C. silver-w; gyh-bk. tarnish. Malleable.	Sol. *nit.*	Fus.
C. gold-yw; wh: Sectile; malleable.	*Nit.* not sol.	Fus.
C. brass-yw—bronze-yw, and steel-gy.	*Nit.* pale-gn. sol.	Fus. *Bor.* violet-blue.
C. pinchbeck-bn; copper-r—bh. tarnish: Brittle.	*Nit.* sol. except silica.	Odor garlic; w. fumes; bh. flame.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Streak.*
•Amalgam, 467. *Ores Mer.*	2—3·5	10·5—14	I: Mas.	Silver-w.
*Newkirkite, 446. *Red hematite.*	3—3·5	3·8—3·9	In small needles.	
*Zinkenite, 514. *Ant. ores.*	"	5·2—5·4	VI: Mas.	
*Native Antimony, 473.	"	6·6—6·8	VI., cleav: Lam. mas.	Tin-w.
•Berthierite, 513. [*Prim.*			Long prisms; fib. mas.	
*Native Arsenic, 475.	3·5	5·6—5·8	VI: Imit, col. mas.	Tin-w, lead [gray.
*Stromeyerite, 504.	3—4	6·2—6·3	Massive, gran.	Shining.
Gray Copper, 497.	2·75—4	4·1—5	I. Tetrahed.; mas.	
•Manganblende, 529.	3·5—4	3·9—4·1	I, cleav: Mas.	Dark-gn.
Blende, 530.	"	4—4·1	I, cleav!	Yw, rdh-bn.
Copper Pyrites, 494.	"	4—4·2	II: Mas.	Gnh-bk.
*Tin Pyrites, 496. *Prim.*	"	4·3—4·4	I: Mas.	Bk.
Tennantite. 499.	"	4·3—4·5	I: Mas.	Rdh-gy.
*Antimonial Silver, 474.	"	9·4—9·8	III, Mas.	Tin-w.
Magnetic Pyrites, 489.	3·5—4·5	4·5—4·7	VI: Mas.	dark gyh-bk.
*Arsenical Silver, 476.	4	9·4	Mam, lam; mas.	
Manganite, 441.	4—4·5	4·3—4·4	III: Col, mas.	Rdh-bn, bkh.
Platinum, 459.	"	16—19	Irreg. masses, grains.	Steel-gray.
Seybertite, 301. *Prim.*	4—5	3—3·1	Fol! mas.	Pale, rdh-bn.
Native Iron, 458.	"	7·3—7·8	I: Mas.	Shining.
Brown Iron Ore, 451.	4·5—5·5	3·9—4	III: Mam, bot, mas.	Ywh-bn.
•Selenpalladite, 462.			VI, Hexag. tables, fol!	
•Palladium, 461. *Platinum.*	"	11·8-12·5	Grains. rad. structure.	Steel-gy—w.
Crichtonite, 455. *Prim.*	5—5·5	4·4—4·8	VI, cleav: Mas.	Met; bk.
Hausmannite, 437.	"	4·7—4·8	II: Mas.	Chesnut-bn.
Yttro-Columbite, 433.	"	5·3—5·5		Gy.
*Nickel Stibine, 477.	"	6·4—6·5	I: Mas.	
*White Nickel, 480.			I: Mas.	
Wolfram, 436. *Prim.*	"	7·1—7·4	III: Coarse col; lam; [mas.	Dark rdh-bn.
Leucopyrite, 482.	"	7·2—7·4	III: Mas.	Gyh-bk.
Copper Nickel, 479.	"	7·6—7·7	III: Mas.	Pale bnh-bk.
•Arsenid of Manganese, 488.	5—5·5 ?	5·5—5·6	Bot; mas.	
Chromic Iron, 447. *Serp.*	5·5	4·3—4·5	I; oct. cryst: Mas.	Bn.
Nickel Glance, 481.	"	6—6·2	I: Lam; mas.	
Cobaltine, 485. *Prim.*	"	6·2—6·4	I: Mas.	Gyh-bk.
*Cobalt Pyrites, 487. *Prim.*	"	6·3—6·4	I: Mas.	
*Terarsenid of Cobalt, 486.		6—6·7	Radiated.	Dull lead-gy.
*Pitchblende, 435.	"	6·4—6·5	Mas, bot, grains.	Bk.
•Antimonial Nickel, 478.	"		Thin hexag. plates.	Rdh-bn.
Psilomelane, 439.	5—6	4—4·4	Bot, mas.	Bnh-bk, shin.
Columbite, 434. *Prim.*	"	5·9—8	III: Mas.	Dark rdh-bn, bnh-bk.
Yenite, 450. *Prim.*	5·5—6	3·8—4	III: Col, mas.	Bk, gnh, bnh.
Mispickel, 483. *Prim.*	"	6—6·2	III: Mas.	Dark gyh-bk.
Specular Iron, 452.	5·5—6·5	4·5—5·1	VI: Gran, mas.	Cherry-red, [rdh-bn.
Magnetic Iron Ore, 453.	"	5—5·1	I. mas.	Bk.
Franklinite, 454. *Prim.*	"	4·8—5·1	I: Mas.	Dark rdh-bn.
Smaltine, 484.	5·5	6·4—6·5	I: Imit; mas.	Gyh-bk.
•Mohsite, 456. *Prim.*	6—6·5		VI.; often twins.	
White Iron Pyrites, 490.	"	4·6—4·9	III: Rad; crests; mas.	Gyh, bnh-bk.
*Braunite, 438.	"	4·8—4·9	II: Mas.	Bnh-bk.
Iron Pyrites, 491.	"	4·8—5·1	I. Imit. mas.	Bnh-bk.
*Polymignite, 431. *Prim.*	6·5	4·7—4·9	III; crystals long and [striated.	Dark-bn.
Iridium, 460. *Platinum.*	6—7	19—21	VI: Grains.	

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. silver-w: Brittle.	*Nit.* sol.	Mercury vol.
C. brilliant-bk: Lustre met., splendent.		
C. steel-gy.		Fus. in candle; before
		blowpipe vol.
C. tin-w: Rather brittle.		Fus! w. fumes.
C. dark steel-gy, gyh-b,- pinchbeck-bn;		Fus! fumes of ant. bk.
often iridescent. [Brittle.		slag. mag. [w. fumes.
C. tin-w, lead-gy, tarnishes to dark-gray:	[copper plate.	Garlic odor, bh. flame;
C. steel-gy: Sectile.	Sol. *nit.* silvers	Fus!
C. steel-gy . . iron-bk: Rather brittle.		Fus; fumes arsen, ant.
C. iron-bk; tarnish bn: L. submet.	Pulv. *mur.* fetid.	Fus. dif!! [fumes.
C. bn, bk: Trl—op: L. submet.	*Nit.* fetid.	Iufus. strong heat, w.
C. brass-yw; often tarnished.	Sol. *nit.* gn.	On char. fus. dif.
C. steel-gy, ywh: Brittle.		Sulph. fumes; fus. bk.
C. bkh-lead-gy; tarnish dark-gy.		Arsen. fumes,blue flame.
C. silver-w, tin-w.		Fumes ant; gy. glob;
		finally glob. of silver.
C. bronze yw . . copper-r.	Dilute *nit.* sol.	Sulph. odor; fus.
C. silver-w; tarnished often bkh: Sectile.		Garlic odor; fus, glob.
C. dark steel-gy . . iron-bk: Sbtrl—op.		Infus; *Bor.*violet-b. glob.
C. perfect steel-gy: Ductile.	Hot *nit-mur.* sol.	Infus.
C. rdh-bn: Lustre submet—pearly.		Infus.
C. iron-gy: Acts on the magnet; malleable.		
C. bn, bkh-bn, ywh-bn: Sbtrp—op; not		Bk. and magnetic. Infus.
C. w, gyh-w: Brittle. [act on magnet.		In tube red ring of selen.
C. steel-gy—silver-w: Malleable.		Infus; with *sulphur*, fus.
C. dark iron-bk: Op: Brittle; slightly mag.	Sol. strong *mur.*	Unaltered. [glob.
C. bnh-bk.	Hot *mur.* odor.	Oxyd. flame, amethyst
C. bk: Op: Lustre submet.	No action.	Inf. *Bor.* sol.
C. steel-gy . . silver-w: Brittle.		Partly vol; w. on char.
C. tin-w.		Arsen.: *Phos.* brit. glass.
C. dark-gyh—bnh-bk: Op.		Dec.fus.dif; *Bor.*gn.bead
C. silver-w . . steel-gy: Brittle.		Fus.no arsen.odor. *Phos.*
		deep-red glob.
C. copper-red: Brittle.	Gn. coating *nit.*	On char. fus; arsen. odor.
C. gyh-w.		Burns b. flame; falls to
[mag.		powder; high heat ars.
C. iron-bk . . bnh: Brittle: Often slightly		Inf: *Bor.* fine gn; fus.dif.
C. silver-w, steel-gy.		Dec!, Sul. arsen. sub-
		limes in glass tube.
C. silver-w, rdh.		On char. arsen; bk. glob.
		mag; *Bor.* b. glob.
C. pale steel-gy, rdh; tarnish copper red.		Dec! on ch. *Bor.* b., sul.
C. lead-gy . . steel-gy.		On ch. ars; yw. coating.
C. gyh, bnh, velvet-bk: Lus. submet, dull.		Infus: *Bor.* gray scoria.
C. light copper-r . . violet: Lustre splend.		Antimony sublimes.
C. bk, gyh—dark steel-gy: Brittle.	*Mur.* sol. odor.	*Bor*, violet.
C. gyh, bnh-bk; bk: Lustre submet.		Infus: *Bor.* fus. dif.
[submet.		
C. iron-bk . . dark gyh, bnh: Brittle. Lus.	Sol. *mur.* odor.	Fus. glob. mag.
C. silver-w . . steel-gy: Brittle.	Sol. *nit.*	On char. glob. mag.
C. dark steel-gy—iron-bk.	Hot *mur.* sol.	Infus: *Bor.* gn. glass.
C. iron-bk; attract. by mag.	Hot *mur.* sol.	Infus: *Bor.* oxyd. flame.
		rdh. glass. [fumes.
C. iron-bk: Acts on the needle.	Hot *mur.* sol.	Infus. high heat, zinc
C. tin-w . . steel-gy.	Pulv., red fumes	Arsen. odor, fus. gyh-bk.
	nit.	pearl; mag: *Bor.*b.glass.
C. iron-bk.		
C. pale bronze-yw; gnh, gyh: Brittle.	*Nit.* sol.	Sulph. fumes.
C. dark bnh-bk: Lustre submet: Brittle.	Hot *mur.* odor.	[heat fus.
C. light bronze-yellow. [met, splend.	Sol. hot. *nit.* ex-	Odor of sulph., r.,at high
C. bk: Fracture brilliant: Lustre sub-	[cept sul.	Inf. *Bor.* fus! col. glob.
C. tin-w, pale steel-gy: Brittle.		With *nitre*, strong odor.

ARRANGEMENT OF THE SPECIES IN CLASS II., SECTION II., ACCORDING TO THEIR SPECIFIC GRAVITIES.

Plumbago,	2—2·1	Manganite,	4·3—4·4	Franklinite,	4·8—5·1
Hisingerite,	3—3·1	Chromic Iron,	4·3—4·5	Miargyrite,	5·2—5·4
Seybertite,	"	Tennantite,	"	Zinkenite,	"
Newkirkite,	3·8—3·9	Crichtonite,	4·4—4·8	Yttro-Columbite,	5·3—5·5
Yenite,	3·8—4	Gray Antimony,	4·5—4·7	Rionite,	5·5—5·6
Brown Iron Ore,	3·9—4	Varvacite,	"	Antimon. Sul't Silver,	"
Manganblende,	3·9—4·1	Magnetic Pyrites,	"	Arsenid of Mang.	"
Blende,	4—4·1	Molybdenite,	4·5—4·8	Jamesonite,	5·5—5·8
Copper Pyrites,	4—4·2	White Iron Pyrites,	4·6—4·9	Vitreous Copper,	"
Psilomelane,	4—4·4	Hausmannite,	4·7—4·8	Native Arsenic,	5·6—5·8
Sternbergite,	4·1—4·3	Polymignite,	4·7—4·9	Graphic Tellurium,	5·7—5·8
Olivenite,	"	Braunite,	4·8—4·9	Bournonite,	"
Gray Copper Ore,	4·1—5	Pyrolusite,	4·8—5	Dark Red Silver,	5·7—5·9
Tin Pyrites,	4·3—4·4	Specular Iron,	4·8—5·1	Native Tellurium,	5·7—6·1

CLASS III. HYPOGÆA.

Names of Species.	*Hardness.*	*Sp. Grav.*	*Structure.*	*Streak.*
*Scheererite, 541.	Soft	0·65	Cryst. grains; small acic. cryst.	Pearly.
Mineral Caoutchouc, 543.	Soft	0·9—1·25		Resinous.
Bitumen, 544.	0—2	1·07-1·16	Solid or liquid.	Resinous.
Retinite, 542.	1·5—2	1·1—1·15	Roundish masses.	Sub-resinous.
Bituminous Coal, 545.	1—2·5	1·2—1·5		Resinous.
Anthracite, 546.	2—2·5	1·4		Submet..res.
Amber, 540.	"	1—1·1		Res.
*Mellite, 539. *Brown coal.*	"	1·5—1·6	II: Mas.	Res..vit.

EXPLANATION OF THE ABBREVIATIONS WHICH HAVE BEEN EMPLOYED, AND OF THE MANNER OF USING THE PRECEDING CLASSIFICATIONS.

117. The italicized words following the names of the species, point out, very generally, the kind of strata in which the species occur, and also, in some instances, the associated minerals. We have omitted, however, any statement of the rock, when the species are found in both primary and secondary strata. The abbreviations employed are as follow:

Prim.	Primitive.	Volc.	Volcanic.	Gran.	Granite.
Amyg.	Amygdaloidal.	Serp.	Serpentine.	Limest.	Limestone.

The Roman numerals in the column of structure designate the crystallographic class to which the species belong, as follows:

I.	Monometrica.	III.	Trimetrica.	V.	Triclinata.
II.	Dimetrica.	IV.	Monoclinata.	VI.	Tetraxona.

Variegated Copper,	6—6·1	Leucopyrite,	7·2—7·4	Native Gold,	12—20
Nickel Glance,	6—6·2	Molybdic Silver,	7·2—8	Platinum,	16—19
Mispickel,	"	Columbite,	"	Iridium,	19—21
Acicular Bismuth,	6·1—6·2	Native Iron,	7·3—7·8		
Arsenical Antimony,	6·2	Telluric Bismuth,	7·5—7·6	*Minerals in this sub-section, whose specific gravities have not been determined.*	
Brittle Silver Ore,	6·2—6·3	Galena,	7·5—7·7		
Polybasite,	"	Cinnabar,	8—8·1		
Stromeyerite,	"	Bitelluret of Lead,	8·1—8·2		
Cobaltine,	6·2—6·4	Telluric Silver,	8·412	Iodic Silver.	
Cobalt Pyrites,	6·3—6·4	Cobaltic Galena,	8·4—8·5	Flexible Silver Ore.	
Nickel Stibine,	6·4—6·5	Native Copper,	8·5—8·6	Bismuthic Silver.	
Pitchblende,	"	Arsenical Silver,	9·4	Feather Ore of Lead.	
Sulphuret Bismuth,	6·5—6·6	Antimonial Silver,	9·4—9·8	Eucairite.	
Terarsenid of Cobalt,	6·6–6·7	Auro-Tellurite,	10—11	Capillary Pyrites.	
Native Antimony,	6·6—6·8	Native Silver,	"	Berthierite.	
Clausthalite,	6·8—7·2	Amalgam,	10·5—14	Selenpalladite.	
Foliated Tellurium,	7—7·1	Native Lead,	11—12	White Nickel.	
Vitreous Silver,	7·1—7·4	Palladium,	11·8—12·5	Antimonial Nickel.	
Wolfram,	"	Native Mercury,	13—14	Mohsite.	

CLASS III. HYPOGÆA.

Color, Diaphaneity, &c.	*Acids.*	*Blowpipe.*
C. w: Feel not greasy: Friable.		Inflames! burns with much smoke; may be fused into an oily liq'd.
C. bkh-bn: Sbtrl—op: Elastic, flexible.	Fus!	Burns with yw. flame, bituminous odor.
C. bk, bnh, rdh, yw: Fracture conchoidal.	Fus!!	Inflames! bitum. odor.
C. light, ywh-bn, gn, yw, r, bn; striped: Sbtrp—op.	Fus!	Inflames, peculiar fragrant odor.
C. and St. bk. or bn: Opaque.	Infus.	Burns with much flame.
C. bk, bnh; often irisedly tarnished: Op.	Infus.	Burns with little or no flame.
C. yw, r, bn, w: Trp—trl.		Burns with yw. flame and agreeable odor.
C. honey-yw; rdh, bnh: St. w: Trp—trl. Sectile.		Not inflam., blackens in candle, decomposed in boiling water.

The following are the explanations of the remaining abbreviations:

	Lustre.
Ad.	Adamantine.
Met.	Metallic.
P'ly, P'rly.	Pearly.
Res.	Resinous.
Splend.	Splendent.
Submet.	Submetallic.
Vit.	Vitreous.

	Cleavage.
Dist.	Distinct.
Ind.	Indistinct.
Perf.	Perfect.
Imp.	Imperfect.
Em.	Eminent.
Cleav.	Cleavable.

	Structure.
Agg, aggreg.	Aggregated.
Bot.	Botryoidal.
Col.	Columnar.
Cryst.	Crystalline.
Del.	Deliquescent.
Div.	Divergent.
Effl.	Efflorescent.
Fib.	Fibrous.
Fol.	Foliated.
Imit.	Imitative.
Mam.	Mammillary.
Mas.	*Granularly* massive and amorphous.
Pulv.	Pulverulent.
Rad.	Radiated.
Ren.	Reniform.

Stalac.	Stalactitic.
Stel.	Stellular.
Tab.	Tabular.
	Color, &c.
C.	Color.
B, bh.	Blue, bluish.
Bn, bnh.	Brown, brownish.
Bk, bkh.	Black, blackish.
Gn, gnh.	Green, greenish.
Gy, gyh.	Gray, grayish.
R, rdh.	Red, reddish.
Yw, ywh.	Yellow, yellowish.
W, wh.	White, whitish.
Op.	Opaque.
Trl.	Translucent.
Sbtrl.	Subtranslucent.
Trp.	Transparent.
Trpncy.	Transparency.
Sbtrp.	Subtransparent.
St.	Streak.
T.	Taste.
Fr.	Fracture.
Sect.	Sectile.
Argil.	Argillaceous.
Lam.	Laminæ.
Flex.	Flexible.
	Acids.
Mur.	Muriatic acid.
Nit.	Nitric acid.
Sul.	Sulphuric acid.
Ef.	Effervescence.

Sol.		Soluble.
Insol.		Insoluble.
Gel, gelat.		Gelatinize.
Precip.		Precipitate.
Sil.		Silica.
Sul.		Sulphur.
Decomp.		Decomposed.
Exc't.		Except.
Pulv.		Pulverized.
		Blowpipe.
Char.		Charcoal.
Bor.	The re-agents.	Borax.
Soda.		Carbonate of Soda.
Phos.		Salt of Phosphorus.
Fus, infus.		Fusible, infusible.
Dif.		Difficult, difficultly.
Vol.		Volatile.
Dec.		Decrepitate.
Defl.		Deflagrates.
Det.		Detonate.
Exf.		Exfoliate.
Int, intum.		Intumesce.
Glob.		Globular.
Vesic.		Vesicular.
Unalt.		Unaltered.
Bkns.		Blackens.
Mag.		Magnetic, or capable of acting on mag. needle.
Phos.		Phosphorescent.
Sulph.		Sulphurous fumes and odor.
Ars, arsen.		Arsenical fumes and alliaceous odor.
Ant.		Fumes of antimony.

The interjectional mark (!) following a word, is equivalent to the intensive adverb *very;* it is a substitute for the word *easily*, when following *fusible;* when doubled, as, (!!), the assertion is still stronger. The latter, employed as follows, *fus. dif!!*, implies that fusion takes place on the edges only.

An asterisk has been affixed to the names of species not known to be American.

The expression, *fol!*, designates a highly foliated structure, and very easily separable laminæ, as in *mica*.

Fol., a highly foliated structure, but laminæ less easily separable; as *anhydrite*, *native magnesia*.

Cleav!, an eminent cleavage; as in *calcareous spar*, *galena*.

Cleav., cleavage obtainable, but with less facility; as in *celestine*, *spathic iron*.

The colors of usual occurrence in a particular species are separated from those of occasional occurrence by a semicolon (;). Two dots, as .., between two colors, signifies *inclining to*, as w .. r, white *inclining to* red; and when written ; .. it is to be understood as signifying, *sometimes inclining to;* w ; .. pale r, white, *sometimes inclining to* pale red.

118. The translations of a few examples of these abbreviated expressions will suffice to render the whole easily intelligible.

Species *Spathic Iron*, p. 126.

Color yellowish-gray, ash-gray, or greenish-gray; sometimes reddish. Subtranslucent. Pulverized it effervesces with nitric acid. Before the blowpipe it blackens, and becomes capable of influencing the magnetic needle, but it does not fuse. With *borax* it forms a green globule.

Species *Comptonite*, p. 130.

Color white: Subtransparent—translucent. When pulverized it gelatinizes in nitric and muriatic acid. Before the blowpipe it intumesces, becomes opaque, and fuses into a vesicular globule.

Species *Axinite*, p. 134.

Color clove-brown; sometimes inclining to plumb-blue and pearl-gray. Transparent—subtranslucent. Easily fusible before the blowpipe, with intumescence, into a dark green glass.

Species *Quartz*, p. 134.

Infusible alone. With *soda* it fuses easily, attended with effervescence, into a transparent glass.

Species *Topaz*, p. 134.

Infusible alone. With *borax* it slowly forms a transparent glass.

Species *Pyromorphite*, p. 140.

Color green or brown, sometimes gray. Streak yellow. Subtransparent—subtranslucent. Soluble in hot nitric acid, without effervescence. Fusible, on charcoal, into a globule, which assumes a crystalline form on cooling.

The above examples are probably sufficient to elucidate the abbreviated expressions.

119. The manner of using these classifications may be illustrated by an example in each. The obvious characters of the specimen selected for illustrating the classification, dependent on crystallography, may be supposed to be as follow:

Crystalline form, according to the indications of secondary planes, a right square prism, or octahedron; cleavage distinct parallel with M, but not easily obtained. Lustre scarcely shining —vitreous inclining to pearly; hardness about 5·5 *; specific gravity less than* 3·5, *as determined by the hand merely.*[*] *Color grayish-white. Streak grayish-white. Subtranslucent.*

From the character of its crystallization and its lustre, the species belongs to the class Dimetrica, and section unmetallic. We pass on to those whose hardness is about the same with the specimen under examination. The first we may examine is *Humboldtilite*, which has a hardness represented by 5. This species, however, disagrees in color. *Hausmannite* has too high specific gravity, and different cleavage, lustre, and color. *Scapolite* agrees in specific gravity, that is, as far as can be determined by the hand; also in cleavage, lustre, color, and streak. Our specimen, therefore, belongs to this species. This may be rendered more certain, if there is a doubt, by examining the characters of the species that follow it, and by determining accurately, if desired, its specific gravity. In general, an accurate knowledge of this last character will not be necessary, and seldom will there be required any thing more than an approximate measurement of the inclinations of primary planes. When an uncertainty remains, after examining all the characters, the extended descriptions of those species between which the doubt lies, given in the descriptive part of this treatise, may be consulted.

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[*] This method of approximate determination requires but little delicacy of feeling, judgment, or practice, and frequently by the use of it the longer operation with balances may be avoided.

120. For an exemplification of the method of using the second of the artificial classification, we may select a specimen which has the following characters: *Tasteless; a grayish-green color; white streak; vitreous lustre, somewhat inclining to pearly; subtranslucent; hardness about 5·5; structure imperfectly crystalline, but sufficiently distinct to evince that it does not belong to either of the two first crystallographic classes.** The specimen is from a primitive rock. A preliminary trial with hot acids affords no action, but with the blowpipe fusion may be obtained. A trial with the hand merely, shows that its specific gravity is not as high as 4.

This species evidently belongs to the class *Entogæa*, to the section *unmetallic*, since its lustre is not metallic, and the subsection A, in which the species have a white or grayish streak. We therefore turn to this subsection, page 124, and pass on till we arrive at those species in which the hardness is about that above given. We may commence our comparative examination with the species *natrolite*, in which H.=4·5—5·5. From this and the following species, *Poohnahlite*, it is excluded by its color, and also by its occurrence in primitive rocks. Its color, besides other characters, excludes it from the five following species. From the next, *triphyline*, it differs in lustre and its solubility with acids. Its color and occurrence in primitive rocks, distinguish it from the four following species: its specific gravity and blowpipe characters from *calamine;* its lustre and action with acids and the blowpipe from *datholite;* its color and action with acids and the blowpipe from *sphene;* (passing by some species of different color,) it differs from *Troostite* and *Yttro-Columbite* in specific gravity, and other characters; with *hornblende* the similarity is close, but it differs in its fusibility. It is distinct from *lazulite* in color. With *pyroxene* it agrees in being found sometimes in primitive rocks, in specific gravity below 4, in structure, in lustre vitreous inclining to pearly, in color, in diaphaneity, and in its action with acids and the blowpipe. It is therefore obviously a specimen of this species. To remove all doubt, some of the following species might be examined, and the full descriptions of the species consulted, if necessary; and also we might determine with more accuracy the specific gravity. By using all the characters given, it is believed that in all instances, excepting in cases of decomposed species, this classification will suffice for the determination of minerals.

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* Frequently we may decide that a mineral does not belong to one, two, or more of the crystallographic classes, when we cannot determine as to the particular class.

PART VI.

DESCRIPTIVE MINERALOGY.

A TABULAR VIEW
OF THE
NATURAL CLASSIFICATION OF MINERALS.*

CLASS I.—EPIGÆA.

ORDER I. RHEUTINEA.

Genus 1. Aer.

Gaseous.

Sp. 1. A. terrenus,	*Carburetted Hydrogen.*
2. A. Hydrogenicus,	*Hydrogen.*
3. A. phosphoricus,	*Phosphuretted Hydrogen.*
4. A. fetidus,	*Sulphuretted Hydrogen.*
5. A. azoticus,	*Nitrogen.*
6. A. Atmosphericus,	*Atmospheric Air.*
7. A. Carbonicus,	*Carbonic Acid.*
8. A. Sulphurosus,	*Sulphurous Acid.*
9. A. muriaticus,	*Muriatic Acid.*

Genus 2. Aqua.

Liquid.

Sp. 1. A. limpida,	*Water.*
2. A. Sulphurica,	*Sulphuric Acid.*

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* An explanation of the names of the classes and orders, and their characters, have been given in §§ 113 and 114.

ORDER II. STERINEA.

Genus 1. ACIDUM.

H=1—2. G=1.4—3.7. *Taste weak.*

Sp. 1. A. Boracicum,	*Boracic Acid.*
2. A. Arsenosum,	*Arsenous Acid.*

Genus 2. BORAX.

H=2—2.5. G=1.7—1.8. *Taste sweetish alkaline.*

Sp. 1. B. obliquus,	*Borax.*

Genus 3. ALUMEN.

H=2—3. G=1.5—1.9. *Taste styptic.*

Sp. 1. A. officinale,	*Native Alum.*
2. A. volcanicum,	*Solfatarite.*
3. A. Magnesicum,	*Magnesian Alum.*
4. A. Ammoniacum,	*Ammonia Alum.*

Genus 4. NATRON.

H=1—3. G=1.4—2.2. *Taste alkaline.*

Sp. 1. N. Gay-Lussianum,	*Gay-Lussite.*
2. N. efflorescens,	*Natron.*
3. N. permanens,	*Trona.*

Genus 5. SAL.

H=2. G=2.2—2.3. *Taste purely saline.*

Sp. 1. S. cubicum,	*Common Salt.*

Genus 6. PICRALUM.*

H=1.5—2.5. G=1.4—2.8. *Taste saline and bitter.*

Sp. 1. P. Glauberium,	*Glauber's Salt.*
2. P. Thenardianum,	*Thenardite.*
3. P. rhombicum,	*Epsom Salt.*
4. P. Reussii,	*Reussite.*
5. P. volcanicum,	*Mascagnine.*
6. P. Vesuvianum,	*Aphthitalite.*
7. P. octahedrum,	*Sal-Ammoniac.*
8. P. deliquescens,	*Nitrate of Magnesia.*
9. P. tenellum,	*Nitrate of Lime.*

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* Πικρὸς, *bitter*, and ἅλς, *salt*. The aspirate has been dropped in the composition of this and similar words, for the sake of euphony.

Genus 7. NITRUM.

H=1.5—2. G=1.9—2.1. *Taste cooling and saline.*

Sp. 1.	N. rhombohedrum,	*Nitrate of Soda.*
2.	N. rhombicum,	*Nitrate of Potash.*

Genus 8. VITRIOLUM.

H=2—2.5. G=1.8—3.2. *Taste astringent and metallic; nauseous.*

Sp. 1.	V. Martiale,[*]	*Copperas.*
2.	V. hexagonum,	*White Copperas.*
3.	V. parasiticum,	*Yellow Copperas.*
4.	V. Cyprium,	*Blue Vitriol.*
5.	V. Zincicum,	*White Vitriol.*
6.	V. Cobalticum,	*Cobalt Vitriol.*
7.	V. Uranicum,	*Johannite.*
8.	V. bicolor,	*Botryogen.*

Genus 9. GÆALUM.[†]

H=2.5—3.5. G=2.7—2.9. *Taste weak.*

Sp. 1.	G. obliquum,	*Glauberite.*
2.	G. columnare.	*Polyhalite.*

CLASS II.—ENTOGÆA.

ORDER I. HALINEA.

Genus 1. ASTASIALUS.[‡]

H=1.5—2. G=1—2.5. *Decomposed in the flame of a candle.*

Sp. 1.	A. phytogeneus.[§]	*Oxalate of Lime.*

Genus 2. CRYALUS.[‖]

H=2.25—2.5. G=2.9—3. *Fusible in the flame of a candle.*

Sp. 1.	C. fusilis,	*Cryolite.*

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[*] The salts of iron were termed Martial by the alchemists, from Mars, the alchemistic name of iron.

[†] Γαῖα, *earth*, and ἅλς, *salt*, in allusion to the composition and slight solubility of the species.

[‡] Ἄστατος, *unstable*; alludes to the facility with which the species is decomposed.

[§] Φυτογενεος, *originating from plants*; the species is supposed to be of vegetable origin.

[‖] Κρύος, *ice*, and ἅλς, *salt*; from the ready fusibility of the mineral.

Genus 3. ALUMINUS.

H=5. G=2.7—2.8.

Sp. 1. A. rhombohedrus,	*Alum Stone.*

Genus 4. FLUELLUS.

H=4—5.5. G=2.9—3.4.

Sp. 1. F. pyramidalis,	*Fluellite.*
2. F. octahedrus,	*Fluor Spar.*
3. F. hexagonus,	*Apatite.*
4. F. obliquus,	*Wagnerite.*
5. F. rhombicus,	*Herderite.*
6. F. Childrenii,	*Childrenite.*

Genus 5. ASTRALUS.[*]

H=3.5—4. G=2.3—2.4. *Mostly stellularly and hemispherically columnar.*

Sp. 1. S. rhombicus,	*Wavellite.*

Genus 6. GYPSALUS.[†]

H=1.5—3.5. G=2.3—3. *One or more cleavages very perfect and easily obtained. Contain lime.*

Sp. 1. G. stellatus,	*Pharmacolite.*
2. G. rhombicus,	*Haidingerite.*
3. G. rhomboideus,	*Gypsum.*
4. G. rectangulus,	*Anhydrite.*
5. G. Cobalticus,	*Roselite.*
6. G. fusilis,	*Hydroboracite.*

Genus 7. CALCIUS.[‡]

H=2.5—4. G=2.5—3.3. *Contain lime.*

Sp. 1. C. rhombohedrus,	*Calcareous Spar.*
2. C. rhombicus,	*Arragonite.*
3. C. Dolomæi,	*Dolomite.*
4. C. decolorans,	*Ankerite.*

Genus 8. MAGNESIALUS.

H=1—4.5. G=2.5—3.2. *Contain magnesia.*

Sp. 1. M. rhombohedrus,	*Rhomb Spar.*
2. M. fibrosus,	*Magnesite.*
3. M. pulvereus,	*Hydromagnesite.*

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[*] Ἄστρον, *a star.*

[†] Γυψος *lime*, and Ἅλς *salt.*

[‡] Calx, *lime.*

ORDER II. BARYTINÆA.

Genus 1. BARALUS.*

H=2.5—4. G=3.3—4.8. *Streak uncolored. Contain strontia or baryta.*

Sp.	1.	B. rubefaciens,†	*Strontianite.*
	2.	B. prismaticus,	*Celestine.*
	3.	B. obliquus,	*Baryto-calcite.*
	4.	B. fusilis,	*Witherite.*
	5.	B. rhombohedrus,	*Dreelite.*
	6.	B. ponderosus,	*Heavy spar.*

Genus 2. SPANIALUS.‡

G=4—5. G=3.4—4.8.

Sp.	1.	S. hexagonus,	*Flucerine.*
	2.	S. dodecahedrus,	*Subsesquifluate of Cerium.*
	3.	S. quadratus,	*Carbonate of Cerium.*
	4.	S. Wollastonii,	*Silicate of Cerium.*
	5.	S. octahedrus,	*Microlite.*
	6.	S. rhombicus,	*Yttro-cerite.*
	7.	S. peritomus,	*Xenotime.*

Genus 3. SCHEELIUS.

H=4—4.5. G=6—6.1.

Sp.	1.	S. pyramidalis,	*Tungstate of lime.*

Genus 4. STIMMIUS.§

H=2.5—3. G=5.5—5.6. *Contain antimony.*

Sp.	1.	S. rhombicus.	*White antimony.*

Genus 5. BISMUTALUS.

H=3—4.5. G=5.9—6.1. *Contain bismuth.*

Sp.	1.	B. ochraceus.	*Bismuth Ochre.*
	2.	B. dodecahedrus.	*Bismuth Blende.*

Genus 6. ZINCALUS.

H=2.5—5.5. G=4.3—4.5. *Contain zinc.*

Sp.	1.	Z. rhombohedrus,	*Calamine.*
	2.	Z. peritomus,	*Electric Calamine.*
	3.	Z. acrotomus,	*Willemite.*
	4.	Z. diatomus,	*Hopeite.*

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[*] Βάρος, *weight*, and ἅλς, *salt*.

[†] In allusion to its tinging flame red.

[‡] Σπάνιος, *rare*, and ἅλς; the species are salts of two rare minerals, cerium and yttrium.

[§] Στίμμι, *antimony*.

Genus 7. MARANTALUS.*

H=3—6. G=3—3.9. *Color darkened on exposure. Contain manganese and iron.*

Sp. 1.	M. rhombohedrus,	*Spathic Iron.*
2.	M. rhombicus,	*Junkerite.*
3.	M. decrepitans,	*Diallogite.*
4.	M. quadratus,	*Triplite.*
5.	M. Dufresni,	*Hetepozite.*
6.	M. fusilis,	*Huraulite.*

Genus 8. AREALUS.†

H=1.5—5. G=2.6—3.8. *Contain iron.*

Sp. 1.	A. cubicus,	*Cube Ore.*
2.	A. trimetricus,	*Scorodite.*
3.	A. Argentiferus,	*Chenocoprolite. D.*
4.	A. rhombicus,	*Triphyline.*
5.	A. radiatus,	*Cacoxenite.*
6.	A. rhomboideus,	*Vivianite.*
7.	A. divergens,	*Anglarite.*
8.	A. rhombohedrus,	*Pyrosmalite.*
9.	A. foliaceus,	*Cronstedtite.*

Genus 9. COBALTALUS.

H=1.5—2. G=3. *Color some shade of red. Contain cobalt.*

Sp. 1.	C. rubellus,	*Cobalt Bloom.*

Genus 10. CRONALUS.‡

H=2—4.5. G=5.3—8.1 *Color white, green, blue, or red. Contain lead.*

Sp. 1.	C. rhombicus,	*White Lead.*
2.	C. quadratus,	*Corneous Lead.*
3.	C. Vesuvianus,	*Cotunnite.*
4.	C. peritomus,	*Cerasite.*
5.	C. acrotomus,	*Leadhillite.*
6.	C. flexilis,	*Dyoxylite.*
7.	C. Angleseanus.	*Anglesite.*
8.	C. amorphus,	*Hedyphane.*
9.	C. resiniformis,	*Plumbo-resinite.*
10.	C. hexagonus,	
11.	var. 1. speciosus,	*Pyromorphite.*
12.	var. 2. alliaceus,	*Mimetene.*
13.	C. pyramidalis,	*Molybdate of Lead.*
14.	C. Vanadicus,	*Vanadate of Lead.*

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* Μαραίνω, *to fade*, alluding to the change of color the species undergo on exposure.

† Ἄρης, *Mars*, the alchemistic name of iron, and ἅλς, *salt*.

‡ Κρόνος, *Saturn*, the alchemistic name of lead, and ἅλς, *salt*.

Sp. 15.	C. ponderosus,	*Tungstate of Lead.*
16.	C. hyacinthus,	*Chromate of Lead.*
17.	C. rubeus,	*Melanochroite.*
18.	C. Vauquelini,	*Vauquelinite.*
19.	C. diatomus,	*Caledonite.*
20.	C. rhomboideus,	*Cupreous Anglesite.*
21.	C. ochraceus,	*Minium.*

Genus 11. CYPRALUS.[*]

H=1—4.5. G=2.5—4.3. *Color green or blue. Contain copper.*

Sp. 1.	C. acrotomus,	*Aphanesite.*
2.	C. cæruleus,	*Blue Malachite.*
3.	C. vulgaris,	*Green Malachite.*
4.	C. amorphus,	*Chrysocolla.*
5.	C. rhombohedrus,	*Dioptase.*
6.	C. speciosus,	*Euchroite.*
7.	C. concentricus,	*Erinite.*
8.	C. rectangulus,	*Liroconite.*
9.	C. hemihedrus,	*Pseudo-malachite.*
10.	C. dystomus,	*Libethenite.*
11.	C. acicularis,	*Olivenite.*
12.	C. exhalans,	*Atacamite.*
13.	C. foliaceus,	*Copper Mica.*
14.	C. decrepitans,	*Copper Froth.*

Genus 12. NICCALUS.

H=2—2.5. *Contain nickel.*

Sp. 1.	U. prasinus,	*Nickel Green.*
2.	U. Herreri,	*Herrerite.*

Genus 13. URANALUS.

H=2—3. G=3.1—3.2 *Contain uranium.*

Sp. 1.	U. ochraceus,	*Uranic ochre.*
2.	U. quadratus,	*Uranite.*

ORDER III. CERATINEA.

Genus CERATUS.

H=1—2. G=5.5—6.5.

Sp. 1.	C. cubicus,	*Horn Silver.*
2.	C. quadratus,	*Horn Quicksilver.*
3.	C. foliatus,	*Iodic Silver.*

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[*] Κύπρος, *copper*, and ἅλς, *salt*.

ORDER IV. OSMERINEA.

Genus 1. HYDROLUS.[*]

H=1—3.5. G=1.4—2.1. *Fusion difficult—infusible.*

Sp. 1.	H. cerinus,[†]	*Halloylite.*
2.	H. argilliformis,	*Kollyrite.*
3.	H. adhærens,	*Scarbroite.*
4.	H. pyrosmicus,[‡]	*Pyrargillite.*
5.	H. Gibbsianus,	*Gibbsite.*
6.	H. tinctus,	*Allophane.*

Genus 2. OPHITIS.[§]

H=2—4. G=2.5—2.9.

Sp. 1.	O. communis,	*Serpentine.*
2.	O. figularis,	*Agalmatolite.*
3.	O. reniformis,	*Kerolite.*

Genus 3. STYLUS.[‖]

H=2—3. G=2.6—2.8. *In prisms of six or twelve sides.*

Sp. 1.	S. hexagonus,	*Pinite.*
2.	S. acrotomus,	*Fahlunite.*

Genus 4. NEMATUS.[¶]

H=2—3. G=2.3—2.7. *Delicately columnar.*

Sp. 1.	N. rectangulus,	*Picrosmine.*
2.	N. scopiformis,	*Osmelite.*
3.	N. gracilis,	*Nemalite.*

Genus 5. MARGARITUS.[**]

H=1.5—3. G=2—3.1. *Lamellar.*

Sp. 1.	M. Magnesicus,	*Native Magnesia.*
2.	M. saponaceus,	*Talc.*

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[*] Ὕδωρ, *water ;* refers to the large proportion of water in the species.

[†] *Waxy*, in allusion to its lustre.

[‡] Πῦρ, *fire*, and ὀσμὴ, *odor*.

[§] An old name of serpentine, derived from the Greek, ὄφις, *a snake*.

[‖] Στύλος, *a column*, in allusion to the hexagonally prismatic forms presented by the species.

[¶] Νῆμα, *a thread ;* refers to the columnar structure of the species.

[**] Μαργαρίτης, *pearl ;* alludes to the lustre.

ORDER V. CHALICINEA.

Genus 1. MICA.

H=2—4.5. G=2.6—3.1. *Structure highly foliated.*

Sp. 1.	M. magarina,*	*Margarite.*
2.	M. hexagona,	*Black Mica.*
3.	M. obliqua,	*Common Mica.*

Genus 2. PHYLLINIUS.†

H=3.5—6. G=2.6—3.4 *Structure foliated.*

Sp. 1.	P. Schilleri,	*Schiller Spar.*
2.	P. æreus,	*Bronzite.*
3.	P. Seybertianus,	*Seybertite.*
4.	P. metallinus,	*Hypersthene.*

Genus 3. VULCANUS.‡

H=3.5—6. G=2—2.7. *Species volcanic or amygdaloidal, and sometimes granitic.*

Sp. 1.	V. rhomboideus,	*Heulandite.*
2.	V. fascicularis,	*Stilbite.*
3.	V. Thomsonianus,	*Thomsonite.*
4.	V. rhombicus,	*Natrolite.*
5.	V. peritomus,	*Mesotype.*
6.	V. crispans,	*Scolezite.*
7.	V. stramineus,	*Carpholite.*
8.	V. tenax,	*Dysclasite.*
9.	V. acutus,	*Epistilbite.*
10.	V. Brewsterianus,	*Brewsterite.*
11.	V. flabelliformis,	*Mesolite.*
12.	V. Comptonianus,	*Comptonite.*
13.	V. quadratus,	*Apophyllite.*
14.	V. efflorescens,	*Laumonite.*
15.	V. gemellus,	*Harmotome.*
16.	V. Phillipsianus,	*Phillipsite.*
17.	V. cubicus,	*Analcime.*
18.	V. dodecahedrus,	*Sodalite.*
19.	V. trapezohedrus,	*Leucite.*
20.	V. rhombohedrus,	*Chabazite.*
21.	V. Levyanus,	*Levyne.*
22.	V. exfolians,	*Gmelinite.*
23.	V. dystomus,	*Datholite.*

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* Alludes to the pearly lustre.

† Φύλλον, *a leaf*, in allusion to the foliated structure of the species.

‡ Refers to the occurrence of the species in rocks of igneous origin.

Genus 4. CLASISTYLUS.*

H=6—6.5. G=2.8—3. *Color light-green; colorless. Commonly botryoidal.*

Sp. 1. C. acrotomus,	*Prehnite.*

Genus 5. NEPHRUS.

H=5.5—7. G=2.9—3.4. *Massive.*

Sp. 1. N. amorphus,	*Nephrite.*
2. N. peritomus,	*Saussurite.*

Genus 6. PETALUS.

H=6—6.5 G=2.4—2.5. *Massive.*

Sp. 1. P. rhombicus,	*Petalite.*

Genus 7. LAZULUS.

H=5—6. G=2.8—3.1. *Color blue or green. Cleavage indistinct.*

Sp. 1. L. amorphus,	*Turquois.*
2. L. rhombicus,	*Lazulite.*
3. L. triclinatus,	*Blue Spar.*

Genus 8. SPATUM.

H=4—6.5. G=2.1—3.1

Sp. 1. S. hexagonum,	*Nepheline.*
2. S. Herschellianum,	*Herschellite.*
3. S. oleaceum,	*Elæolite.*
4. S. opalescens,	*Labradorite.*
5. S. orthotomum,†	*Feldspar.*
6. S. gemellum,	*Pericline.*
7. S. triclinatum,	*Albite.*
8. S. Vesuvianum,	*Anorthite.*
9. S. roseum,	*Latrobite.*
10. S. hemiquadratum,	*Edingtonite.*
11. S. quadratum,	*Scapolite.*
12. S. Gehlenianum,	*Gehlenite.*
13. S. volcanicum,	*Gismondine.*

Genus 9. SPATINIUS.

H=5.5—6.5. G=3—3.5.

Sp. 1. S. decolorans,	*Manganese Spar.*
2. S. rhombohedrus,	*Troostite.*
3. S. reniformis,	*Bustamite.*

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* Κλάω, *to break*, and στύλος, *a column*, in allusion to the resemblance to a broken column, often presented by the crystals of this species.

† Ὀρθός, *straight*, and τέμνω, *I cleave*, refers to the fact, that its two cleavages are at right angles with one another.

Genus 10. AUGITUS.

H=5—7. G=2.9—4.

Sp. 1. A. tabularis,	*Tabular Spar.*
2. A. rhombicus,	*Spodumene.*
3. A. diatomus,	*Pyroxene.*
4. A. dystomus,	*Bucklandite.*
5. A. acrotomus,	*Babingtonite.*
6. A. Protæus,	*Hornblende.*
7. A. phyllinus,	*Anthophyllite.*
8. A. scopiformis,	*Cummingtonite.*
9. A. peritomus,	*Arfwedsonite.*
10. A. rhomboideus,	*Epidote.*
11. A. Withami,	*Withamite.*
12. A. cuspidatus,	*Acmite.*
13. A. Lithicus,	*Amblygonite.*

ORDER VI. HYALINEA.

Genus 1. ANDALUSIUS.

H=7—7.5. G=3.1—3.2.

Sp. 1. A. prismaticus,	*Andalusite.*

Genus 2. EPIMECIUS.*

H=6—7. G=3.1—3.7. *Crystals usually long and slender. Color blue—brown—white.*

Sp. 1. E. cyaneus,	*Kyanite.*
2. E. dissiliens,†	*Diaspore.*
3. E. Sillimanianus,	*Sillimanite.*
4. E. Bucholzianus,	*Bucholzite.*

Genus 3. TURMALUS.

G=7—8. G=3—3.1. *Color black—dark-brown—dark-blue—green—red—white.*

Sp. 1. T. rhombohedrus,	*Turmaline.*

Genus 4. BERYLLUS.

H=7.5—8. G=2.8—3.1. *Color green—bluish—colorless.*

Sp. 1. B. hexagonus,	*Beryl.*
2. B. rhomboideus,	*Euclase.*
3. B. rhombohedrus,	*Phenacite.*

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* 'Επιμηκης, *very long.*

† *Flying in pieces;* alludes to the action under the blowpipe.

Genus 5. SAPPHIRUS.

H=7.5—9. G=3.5—4.6.

Sp. 1.	S. rectangula,	*Chrysoberyl.*
2.	S. octahedra,	*Spinel.*
3.	S. eutoma,	*Automolite.*
4.	S. infusilis,	*Dysluite.*
5.	S. rhombohedra,	*Sapphire.*

Genus 6. ADAMAS.

H=10. G=3.1—3.6.

Sp. 1.	A. octahedrus,	*Diamond.*

Genus 7. TOPAZIUS.

H=8. G=3.4—3.6.

Sp. 1.	T. rhombicus,	*Topaz.*
2.	T. Vesuvianus,	*Forsterite.*

Genus 8. CHRYSOLITHUS.

H=6.5—7.5. G=3.3—3.5.

Sp. 1.	C. rectangulus,	*Chrysolite.*
2.	C. obliquus,	*Ligurite.*

Genus 9. HYALUS.

H=5.5—7. G=2—3.3.

Sp. 1.	H. bicolor,	*Iolite.*
2.	H. acutus,	*Axinite.*
3.	H. rhombohedrus,	*Quartz.*
4.	H. opalinus,	*Opal.*
5.	H. Vulcani,	*Obsidian.*
6.	H. sphærulus,	*Sphærulite.*
7.	H. ferriferus,	*Isopyre.*

Genus 10. BORACIUS.

H=7. G=2.9—3. *Crystals monometric. Color white or gray.*

Sp. 1.	B. hemihedrus,	*Boracite.*

Genus 11. CARBUNCULUS.

H=6—7.5. G=2.9—4.8.

Sp. 1.	C. hemihedrus,	*Helvin.*
2.	C. obliquus,	*Brucite.*
3.	C. acrotomus,	*Humite.*
4.	C. dimetricus,	*Idocrase.*

Sp. 5. C. dodecahedrus,	*Garnet.*
6. C. quadratus,	*Zircon.*
7. C. rhombohedrus,	*Eudialyte.*
8. C. decussatus,[*]	*Staurotide.*
9. C. rhombicus,	*Ostranite.*

ORDER VII.—SCAPTINEA.

Genus 1. Rutilus.[†]

H=3.5—7. G=3.2—6. *Color dark-red—brownish-black.*

Sp. 1. R. Brucii,	*Red Zinc Ore.*
2. R. quadratus,	*Rutile.*
3. R. obliquus,	*Sphene.*
4. R. pyramidalis,	*Anatase.*
5. R. Brookianus,	*Brookite.*
6. R. octahedrus,	*Red Copper Ore.*
7. R. dystomus,	*Pyrochlore.*

Genus 2. Jovius.[‡]

H=6—7. G=6.5—7.1. *Contain tin.*

Sp. 1. J. quadratus,	*Tin Ore.*

Genus 3. Ceritus.

H=5.5.—6. G=3.1—3.2. *Contain cerium.*

Sp. 1. C. rhombohedrus,	*Cerite.*
2. C. rhombicus,	*Thulite.*

Genus 4. Melanophæus.[§]

H=2.5—6.5. G=2.1—5.6. *Color brown—black.*

Sp. 1. M. triclinatus,	*Allanite.*
2. M. Thoriferus,	*Thorite.*
3. M. acicularis,	*Orthite.*
4. M. flammans,	*Pyrorthite.*
5. M. obliquus,	*Gadolinite.*
6. M. Laugieri,	*Titaniferous Cerite.*
7. M. Mengii,	*Æschynite.*

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[*] *Crossed like the letter* X; alludes to the common cruciform crystallization of this species.

[†] *Red and shining.*

[‡] From Jupiter, the alchemistic name of tin.

[§] Μέλας, *black*, and φαιός, *brown*.

Sp. 8.	M. quadratus,	*Œrstedite.*
9.	M. rectangulus,	*Polymignite.*

Genus 5. Columbus.

H=5.5—6. G=5.8—8. *Contain columbium.*

Sp. 1.	C. hemiquadratus,	*Fergusonite.*
2.	C. Berzelii,	*Yttro-Columbite.*
3.	C. rectangulus,	*Columbite.*

Genus 6. Uranius.

H=5—5.5. G=6.4—6.5. *Contain uranium.*

Sp. 1.	U. amorphus,	*Pitchblende.*

Genus 7. Wolframius.

H=5—5.5. G=7.1—7.4. *Contain tungsten.*

Sp. 1.	W. rectangulus,	*Wolfram.*

Genus 8. Manganus.

H=1—6.5. G=3.1—4.9. *Contain manganese.*

Sp. 1.	M. acrotomus,	*Hausmannite.*
2.	M. peritomus,	*Braunite.*
3.	M. informis,	*Psilomelane.*
4.	M. Cupriferus,	*Cupreous Manganese.*
5.	M. rhombicus,	*Manganite.*
6.	M. prismaticus,	*Pyrolusite.*
7.	M. Cobalticus,	*Earthy Cobalt.*
8.	M. terrenus,	*Wad.*

Genus 9. Siderus.*

H=4—6.5. G=5.2—5.3. *Contain iron.*

Sp. 1.	S. Chromicus,	*Chromic Iron.*
2.	S. fibrosus,	*Crocidolite.*
3.	S. Hisingeri,	*Hisingerite.*
4.	S. rhombicus,	*Yenite.*
5.	S. hæmaticus,†	*Brown Iron Ore.*
6.	S. rhombohedrus,	*Specular Iron.*
7.	S. octahedrus,	*Magnetic Iron Ore.*
8.	S. Zinciferus,	*Franklinite.*

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[*] Σίδηρος, *iron.*

[†] Αἱματικός, *bloody*, in allusion to the color of the powder.

Sp. 9.	S. acrotomus,	*Crichtonite.*
10.	S. Mohsianus,	*Mohsite.*

ORDER VIII. METALLINEA.

Genus 1. Ferrum.

Sp. 1.	F. octahedrum,	*Iron.*

Genus 2. Platinum.

Sp. 1.	P. cubicum,	*Platinum.*

Genus 3. Iridium.

Sp. 1.	I. hexagonum,	*Iridium.*

Genus 4. Palladium.

Sp. 1.	P. octahedrum,	*Palladium.*
2.	P. rhombicum,	*Selenpalladite.*

Genus 5. Aurum.

Sp. 1.	A. cubicum,	*Gold.*
2.	A. rhombicum,	*Auro-tellurite.*

Genus 6. Argentum.

Sp. 1.	A. octahedrum,	*Silver.*

Genus 7. Hydrargyrum.

Sp. 1.	H. fluidum,	*Mercury.*
2.	H. dodecahedrum,	*Amalgam.*

Genus 8. Plumbum.

Sp. 1.	P. octahedrum,	*Lead.*

Genus 9. Bismutum.

Sp. 1.	B. octahedrum,	*Bismuth.*
2.	B. Argenticum,	*Bismuth Silver.*

Genus 10. Cuprum.

Sp. 1.	C. octahedrum.	*Copper.*

Genus 11. TELLURIUM.

Sp. 1.	T. hexagonum,	*Tellurium.*

Genus 12. STIBIUM.

Sp. 1.	S. rhombohedrum.	*Antimony.*
2.	S. rhombicum.	*Antimonial Silver.*

Genus 13. ARSENIUM.

Sp. 1.	A. rhombohedrum.	*Arsenic.*

ORDER IX. PYRITINEA.

Genus 1. ARGYRITES.*

H=4—5.5. G=6—9.4. *Color white, or slightly reddish.*

Sp. 1.	A. Argenteus,	*Arsenical Silver.*
2.	A. eutomus,	*Nickel Stibine.*
3.	A. hexagonus,	*Antimonial Nickel.*
4.	A. cupricolor,	*Copper Nickel.*
5.	A. Hoffmanni,	*White Nickel.*
6.	A. decrepitans,	*Nickel Glance.*
7.	A. acrotomus,	*Leucopyrite.*
8.	A. peritomus,	*Mispickel.*
9.	A. octahedrus,	*Smaltine.*
10.	A. hemi-cubicus,	*Cobaltine.*
11.	A. Karsteni,	*Terarsenid of Cobalt.*
12.	A. cubicus,	*Cobaltic Pyrites.*
13.	A. Manganicus,	*Arsenid of Manganese.*

Genus 2. PYRITES.

H=3—6.5. G=4.5—6.1. *Yellowish—yellow.*

Sp. 1.	P. hexagonus,	*Magnetic Pyrites.*
2.	P. rhombicus,	*White Iron Pyrites.*
3.	P. cubicus,	*Iron Pyrites.*
4.	P. alliaceus,	*Arsenid of Copper.*
5.	P. erubescens,†	*Variegated Pyrites.*
6.	P. pyramidalis,	*Copper Pyrites.*
7.	P. capillaris,	*Capillary Pyrites.*

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* Ἄργυρος, *silver;* refers to the color.

† *Blushing;* alludes to the reddish tarnish the mineral speedily assumes on exposure.

ORDER X. GALINEA.

Genus 1. CYPRITES.*

H=2.5—4. G=4.3—5.8. *Contain copper.*

Sp. 1. C. cubicus,	*Tin Pyrites.*
2. C. tetrahedrus,	*Gray Copper.*
3. C. rectangulus,	*Bournonite.*
4. C. dodecahedrus,	*Tennantite.*
5. C. rhombicus,	*Vitreous Copper.*

Genus 2. LUNITES.†

H=1.5—1.4. G=5.5—8.5. *Contain silver.*

Sp. 1. L. Selenicus,	*Eucairite.*
2. L. Cupricus,	*Stromeyerite.*
3. L. dodecahedrus,	*Vitreous Silver.*
4. L. Telluricus,	*Telluric Silver.*
5. L. Auricus,	*Graphic Tellurium.*
6. L. rhombohedrus,	*Polybasite.*
7. L. rhombicus,	*Brittle Silver Ore.*
8. L. peritomus,	*Antim. Sulphuret of Silver.*
9. L. Molybdicus,	*Molybdic Silver.*

Genus 3. LYCITES.‡

H=2—3.5. G=4.5—5.8. *Contain antimony.*

Sp. 1. L. diatomus,	*Gray Antimony.*
2. L. Berthieri,	*Berthierite.*
3. L. Zinkeni,	*Zinkenite.*
4. L. acrotomus,	*Jamesonite.*
5. L. alliaceus,	*Arsenical Antimony.*

Genus 4. PLUMBITES.

H=1.5—3. G=6.8—8.5. *Contain lead.*

Sp. 1. P. cubicus,	*Galena.*
2. P. Cobalticus,	*Cobaltic Galena.*
3. P. Selenicus,	*Clausthalite.*

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* Κύπρος, *copper.*

† From *Luna*, the alchemistic name of silver.

‡ Λύκος, *a wolf*; gray antimony was called "lupus metallorum," *wolf of the metals*, by the alchemists.

Genus 5. ELASMITES.*

H=1—1.5. G=4.2—8.2. *Structure foliated.*

Sp. 1.	E. quadratus,	*Foliated Tellurium.*
2.	E. rhombicus,	*Sternbergite.*
3.	E. rhomboideus,	*Flexible Silver.*
4.	E. hexagonus,	*Molybdenite.*

Genus 6. BISMITES.†

H=2—2.5. G=6.1—7.6. *Very fusible. Contain bismuth.*

Sp. 1.	B. rectangulus,	*Sulphuret of Bismuth.*
2.	B. acicularis,	*Acicular Bismuth.*
3.	B. rhombohedrus,	*Telluric Bismuth.*

Genus 7. ZINCITES.

G=5.5—5.6. *Contain zinc.*

Sp. 1.	Z. flammans,	*Rionite.*

ORDER XI. ADELINEA.

Genus 1. ACARPIA.‡

H=3.5—4. G=3.9—4.1.

Sp. 1.	A. cubica,	*Manganblende.*
2.	A. dodecahedra,	*Blende.*

Genus 2. CERASIA.§

H=1—1.5. G=4.5—4.6.

Sp. 1.	C. rhomboidea,	*Red Antimony.*

Genus 3. RUBELLA.

H=2—2.5. G=5.2—8.1.

Sp. 1.	R. obliqua,	*Miargyrite.*
2.	R. rhombohedra,	*Dark-Red Silver.*
3.	R. florida,	*Light-Red Silver.*
4.	R. peritoma,	*Cinnabar.*

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[*] Ἔλασμα, *a plate of metal.*

[†] Contracted from bismutites, which is derived from bismutum the Latin of bismuth.

[‡] Ἄκαρπος, *sterile;* alludes to the difficulty of reducing the species to the metallic state.

[§] Cerasus, *the cherry tree;* in allusion to the color.

Genus 4. EUCHROA.[*]

H=1.5—2. G=3.4—3.7.

Sp. 1.	E. rubella,	*Realgar.*
2.	E. aurea,	*Orpiment.*

ORDER XII. THEIINEA.

Genus 1. SULPHUR.

Sp. 1.	S. pyramidalis.	*Native Sulphur.*

CLASS III.—HYPOGÆA.

ORDER I. PITTINEA.

Genus 1. MELLIS.

H=2—2.5. G=1.5—1.6. *Transparent—translucent. Color light.*

Sp. 1.	M. pyramidalis,	*Mellite.*

Genus 2. SUCCINUM.

H=2—2.5. G=1—1.1. *Transparent—translucent. Color light.*

Sp. 1.	S. Electrum,	*Amber.*

Genus 3. STEATUS.[†]

G=0.65. *Whitish. Crystalline.*

Sp. 1.	S. acicularis,	*Scheererite.*

Genus 4. BITUMEN.

H=0—2.5. G=0.8—1.2. *Amorphous. Solid individuals opaque, or subtranslucent.*

Sp. 1.	B. fragrans,	*Retinite.*
2.	B. flexile,	*Mineral Caoutchouc.*
3.	B. communis,	*Bitumen.*

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[*] Εὔχροος, *finely colored.*

[†] Στέαρ, *fat,*

ORDER II. ANTHRACINEA.

Genus 1. ANTHRAX.

Lustre unmetallic.

Sp. 1. A. bituminosus,	*Bituminous Coal.*
2. A. lapideus,	*Anthracite.*

Genus 2. PLUMBAGO.

Lustre metallic.

Sp. 1. P. scriptoria.	*Graphite.*

DESCRIPTION OF SPECIES.

CLASS I. EPIGÆA.

ORDER I.—RHEUTINEA.

CARBURETTED HYDROGEN. Aer terrenus.

121. *Gaseous*. G.=0·5555. *Colorless*. *Odor* empyreumatic. Its power of refracting light is represented by 1·504, according to Dulong, that of air being 1.

Composition, 75 parts of Carbon, and 25 of Hydrogen. It burns with a yellow flame, giving out much light.

Obs. This gas may be obtained from stagnant ponds, by stirring their muddy bottom. It is there produced by the decomposition of vegetable substances. Its most abundant sources are beds of coal; it often issues with much force from small cavities in the interior of coal mines, and forms what is termed a *blower*. At Fredonia in the State of New York, there is so copious a discharge of this gas through an aperture in the lime rock, that it is employed for lighting the village.

HYDROGEN. Aer Hydrogenicus.

122. *Gaseous*. G.=0·0694. *Colorless*. *Inodorous* when pure. Its refracting power is equal to ·470.

Hydrogen is one of the elementary substances. It burns with a pale blue flame, producing but little light.

Obs. It is evolved from beds of coal and stagnant ponds.

PHOSPHURETTED HYDROGEN. Aer phosphoricus.

123. *Gaseous*. G.=1·761. *Colorless*. *Odor* alliaceous. *Taste* bitter.

Composition, according to Berzelius, Hydrogen 8·71, and Phosphorus 91·29. It takes fire on coming in contact with the atmosphere.

Obs. This is one of the products of vegetable decomposition, and occurs in bogs and marshy places. It has been supposed to compose the masses of phosphoric matter called Jack-o'-lanterns.

SULPHURETTED HYDROGEN. Aer fetidus.

124. *Gaseous*. G.=1·1912. *Colorless*. *Odor* and *Taste* similar to that of putrescent eggs.

Composition, Sulphur 94·176, and Hydrogen 5·824. Burns with a pale bluish-red flame.

Obs. This gas is found in all sulphurous mineral waters, and is also one of the volatile products of volcanoes.

It occurs abundantly at the Solfataras in Italy, and with few exceptions may be perceived in every volcanic district. The various sulphur waters of the middle and western portions of our country abound with it.

NITROGEN. Aer azoticus.

125. *Gaseous*. G.=·9757. *Colorless*. *Inodorous*. *Tasteless*.

Nitrogen ranks among the elements.

It is neither a combustible nor a supporter of combustion. It therefore extinguishes a lighted candle introduced into it, and is also destructive to life.

Obs. This gas is produced in great abundance over an extent of four or five acres near the town of Hoosic, N. Y. and also issues through the waters of the Lebanon Springs, which are not far distant. These waters have a higher temperature than ordinary.

There are many foreign localities. Among them may be instanced the mineral springs of Cheltenham and Harrowgate.

This gas is supposed to proceed from a decomposition of the atmosphere, and the formation of nitric acid from its oxygen and a small portion of the nitrogen.

ATMOSPHERIC AIR. Aer Atmosphericus.

126. *Gaseous*. *Colorless*. *Inodorous*. *Tasteless*.

Contains Nitrogen 79, and Oxygen 21. Supports combustion and life, and is incombustible.

CARBONIC ACID. Aer Carbonicus.

127. *Gaseous*. G.=1·5245. *Colorless*. *Taste* slightly acid. Excites a pungent sensation in the nostrils.

Composition, Carbon 27·65, Oxygen 72·35. It extinguishes combustion, and destroys life.

Obs. This gas is an abundant product of volcanic countries.

The *Grotto Del Cane*, near Naples, is a constant source of it. This small cave is situated near lake Albano, the supposed crater of an ancient volcano, on whose banks there now exist the natural warm baths of San Germano. Its origin may therefore be presumed to be due to volcanic agency. It may possibly arise from the formation of sulphuric acid by volcanic heat, and the consequent decomposition of carbonate of lime.

Carbonic acid is evolved in large quantities from all chalybeate mineral waters. Saratoga and Ballstown Springs are its most abundant sources in our own country. The mineral waters of Germany are famous as foreign localities.

SULPHUROUS ACID. AER SULPHUROSUS.

128. *Gaseous.* G.=2·234, Thenard. *Colorless.* *Taste* acid. *Odor* pungent.

It consists, according to Berzelius, of Sulphur, 50·144, and Oxygen 49·856. It dissolves readily in water, forming an acid solution, which will redden vegetable blues. It destroys life, and extinguishes combustion.

OBS. Sulphurous acid is an abundant product of most active volcanoes. The sulphur about volcanoes is often produced by the meeting of this gas with sulphuretted hydrogen, causing a mutual decomposition and a deposition of their sulphur.

Sulphurous acid is frequently employed in the arts, as a bleaching material.

MURIATIC ACID. AER MURIATICUS.

129. *Gaseous.* G.=1·2847. *Colorless.* *Smell* pungent. *Taste* acid.

Composition, Hydrogen 2·74, Chlorine 97·26. Berzelius.

OBS. Muriatic acid is one of the constituents of the dense smoke that issues from volcanoes when in a state of action. It is sometimes found in solution in crevices about volcanoes.

WATER. AQUA LIMPIDA.

130. *Liquid.* G.=1. *Colorless.* *Inodorous.* *Tasteless.*

Water becomes a solid at the temperature of 32° F., and forms ice or snow. In the solid state, it always possesses a crystalline structure, and in the condition of snow often presents compound crystals, having a stellated form. The angles of the right rhombic prism composing them are 120° and 60°. (See remarks on these crystals, § 76.)

It is composed of Oxygen 88·94, and Hydrogen 11·06.

SULPHURIC ACID. AQUA SULPHURICA.

131. *Liquid.* G.=1·85. *Colorless.* *Odor* pungent. *Taste* intensely acid.

The composition of the anhydrous acid is, Sulphur 40·14, Oxygen 59·58.

OBS. This acid, in a diluted state, has been found in the neighborhood of several volcanoes. According to Professor Baldassari, it occurs near Sienna, in the cavities of the small volcanic mountain named Zocolino. Pictet asserts, also, that he has distilled it from a cavern near Aix in Savoy. Thenard, however, expresses his doubts whether this acid is ever found in the free state.

ORDER II. STERINEA.

BORACIC ACID. Acidum Boracicum.

Sassolin, *Reuss.*

132. In small scales, apparently six sided tables, and also in stalactitic forms, composed of small scales.

G.=1·48. *Lustre* pearly. *Color* white, except when tinged yellow by sulphur; sometimes gray. *Feel* smooth and unctuous. *Taste* acidulous, and slightly saline and bitter.

Composition, essentially Boron 25·83, Oxygen 74·17. The native stalactitic salt, according to Klaproth, (Beitrage iii. 97,) contains, mechanically mixed, sulphate of magnesia and iron, sulphate of lime, silica, carbonate of lime, and alumina.

It fuses in a candle, and at first tinges the flame green; but this color disappears when the water of crystallization has evaporated. When cooled, the globule has a glassy appearance, and is opaque if any gypsum is present.

Obs. This species has been found most abundantly in the crater of Vulcano, one of the Lipari isles, where it forms a thin layer on the sulphur, and around the fumaroles, or exits of the sulphureous exhalations. The first locality known was Sasso, a city in Sienna, Italy, from which place it derived its name Sassolin. It occurs also in the Lagoni, in Tuscany.

It is obtained for the arts at Pomoranæ, in Tuscany, by causing the volcanic vapors of the region to pass through water, and then evaporating in leaden vessels. The boracic acid thus obtained, is in large crystalline flakes.

ARSENOUS ACID. Acidum Arsenosum.

Arsenious Acid.

133. *Primary form:* the regular octahedron, fig. 4. Pl. I. It occurs usually in minute capillary crystals, stellarly aggregated, investing other substances. Also in botryoidal and stalactitic masses.

H.=1·5. G.=3·698. *Lustre* vitreous or silky. *Streak* white. *Color* white, occasionally with a yellowish or reddish tinge. Transparent—opaque. *Taste* astringent, sweetish.

It contains, according to Berzelius, Arsenic 75·82, Oxygen 24·18.

Before the blowpipe, it is completely volatilized in white fumes. In the internal flame it blackens, and gives out an alliaceous odor.

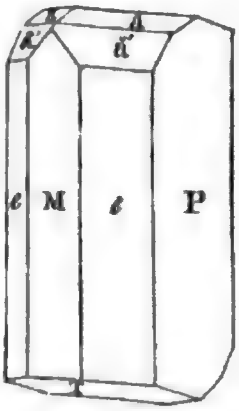
It is soluble in hot water. Sulphuretted hydrogen causes a yellow precipitate.

Obs. It is found accompanying ores of silver, lead, and arsenic, at Andreasberg, in the Hartz, and probably has been formed by the decomposition of some of the above species. It occurs also at Joachimsthal, in Bohemia, at Kapnick, in Hungary, and in the old mines of Biber, in Hanau.

It differs from pharmacolite, which it much resembles, in its solubility. Pharmacolite is insoluble.

BORAX. Borax obliquus.

Pounxa. Swaga. Tincal. Zala. Biborate of Soda.



134. *Primary form:* right rhomboidal prism; T : M=106° 6′, M : P=90°. *Secondary form:* M : *e*=134° 5′, *e* : *e*=88° 9′. ă : ă=120° 23. *Cleavage* parallel with M perfect; less so parallel with *e*.

H.=2—2·5. G.=1·716. *Lustre* vitreous, resinous; sometimes earthy. *Streak* white. *Color* white; sometimes grayish, or with a shade of blue and green. Translucent—opaque. *Fracture* conchoidal. Rather brittle. *Taste* sweetish-alkaline, feeble.

It contains Soda 16·7, Boracic Acid 36·4, Water 46·9.

Intumesces before the blowpipe, and afterwards fuses into a transparent globule, called the glass of borax. It is soluble in water; the solution changes vegetable blues to green.

Obs. Borax was originally obtained from a lake in Thibet, fifteen days' journey from Tisoolumbo, the capital. The water contains both borax and common salt; and being in an elevated situation, is frozen the greater part of the year. The borax is dug in considerable masses from the edges and shallow parts of the lake, and in the course of a short time, the holes thus made are again filled. This crude borax was formerly sent to Europe under the name of tincal, and there purified. It has also been found at the mines of Potosi, in Peru. It occurs also in Ceylon.

This salt is employed in several metallurgical operations as a flux, is sometimes used in the manufacture of glass and gems, and is highly important in the process of soldering.

NATIVE ALUM. Alumen officinale.

135. *Primary form:* the octahedron, fig. 4, Pl. I. *Cleavage* imperfect. Generally in fibrous masses, or in efflorescences.

H.=2—2·5. G.=1·75. *Lustre* vitreous; the fibrous varieties sometimes pearly; occasionally dull. *Streak* white. *Color* white. Transparent—opaque. *Taste* sweetish astringent and acid. *Fracture* conchoidal.

It contains Sulphate of Alumina 21·75, Sulphate of Potash 11·00. and Water 28·125.

Melts before the blowpipe in its water of crystallization, and froths up, producing a spongiform mass of anhydrous alum. It is soluble in from 16 to 20 times its weight of cold, and in little more than its weight of boiling water.

Obs. Alum generally occurs in efflorescences on argillaceous minerals, and more particularly alum slate. Whitby, in Yorkshire, is one of its most noted localities.

In the brown coal, at Tschermig, in Bohemia, it occurs in layers having a fibrous structure. It has also been obtained at the volcanoes of the Lipari isles and Sicily.

Alum is a very important material in the arts. It is used in the manufacture of leather, in dyeing, also as a preventive of putrefaction. Large artificial crystals of an octahedral form are obtained without difficulty from a saturated solution.

SOLFATARITE. Alumen volcanicum.

Soda Alum.

136. Occurs in fibrous crusts; fibres minute.

H.=2—3. G.=1·88. *Lustre* vitreous—pearly—silky. *Streak* white. *Color* white. Outer fibres subtranslucent or opaque; inner usually transparent. *Taste* sweetish, astringent; not differing from that of common alum.

The essential ingredients, as determined by four different analyses, are as follows:

	Sul. Acid.	Alumina.	Soda.	Water.
Thomson, from Mendoza, S. A.,	37·7,	12·0,	7·96,	41·9.
Boussingault, from Rio-Saldana,	36·40,	16·0,	0·00,	46·6.
Hartwell, from Milo,	40·31,	14·98,	1·13,	40·94.
Rose, from Copiapo,	36·97,	14·63,	—	44·64.

The accidental ingredients which the analyses show to be present in minute quantities, are lime, iron, silica, and magnesia. It is much more soluble than common alum.

Obs. It occurs at the Solfataras, in Italy, and many of the natural warm baths of that region; also in the caverns on the island of Milo. It is very abundant at Copiapo, in Chili.

MAGNESIAN ALUM. Alumen Magnesicum.

137. *Structure* fibrous; also compact.

Lustre shining. *Streak* and *Color* snow-white.

It contains, according to Stromeyer, Sulphate of Alumine 38·398, Sulphate of Magnesia 10·820, Sulphate of Manganese 4·597, Water 45·739, Chlorid of Potassium 0·205=99·759.

Obs. It covers the floor of a grotto near Cape Verd, in Southern Africa, to the depth of 6 inches. The roof of the grotto is a reddish quartzose conglomerate, containing manganese and pyrites. It rests on a bed of Epsom Salt, 1¼ inches thick.

AMMONIA ALUM. Alumen Ammoniacum.

138. *Structure* fibrous; may be obtained in regular octahedrons by solution and evaporation.

H.=1—2. G.=1·56. *Lustre* resinous and shining. *Streak* and *Color* grayish-white. Transparent—translucent.

According to the analysis of Mr. mine-commissioner Gruner, (Gilbert's Annalen, lxix. 54,) it contains,

Sulphuric acid,	33·682
Alumina,	10·750
Ammonia,	3·619
Water,	51·000=99·051.

Obs. This mineral has the general appearance of common alum, and when heated exhibits the same phenomena. It occurs at Tackermig, in Bohemia, and was first described by Von Herder, in 1818.

GAY-LUSSITE. Natron Gay-Lussianum.

139. *Primary form:* an oblique rhombic prism; M : M=68° 50′ P : M=83° 30′. *Cleavage* parallel with M perfect; parallel with P less so. Usually in the crystals the edge $\bar{c}$ is truncated.

H.=2—3. G.=1·92—1·99. *Lustre*, (obtained by fracture,) vitreous. *Streak* grayish. *Color* yellowish-white. Translucent. Exhibits *double refraction*. *Fracture* conchoidal. Extremely *brittle*. Not phosphorescent by friction or heat.

Composition, as determined by Boussingault, (Ann. de Ch. et de Ph. xxxi. 270,) is as follows:

Carbonate of Soda,	33·96
Carbonate of Lime,	31·39
Water,	32·20
Alumina,	1·00
Carbonic acid,	1·45.=100

Heated in a matrass, the crystals decrepitate and become opaque. If then applied to the action of the blowpipe, it fuses rapidly into an opaque globule, which is nearly infusible, and has an alkaline taste. In nitric acid, dissolves with a brisk effervescence, and by spontaneous evaporation yields crystals of nitrate of soda, floating in a solution of nitrate of lime. It is partially soluble in water, and reddens turmeric.

Obs. This mineral occurs in abundance at Lagunilla, near Merida, in Maracaibo. Its crystals are disseminated at the bottom of a small lake, in a bed of clay, covering trona. In allusion to its crystalline form, the natives call it *clavos* or *nails*, and distinguish the trona by the name *urao*. It received its present name from M. Cordier, in honor of the celebrated French chemist, Gay-Lussac.

NATRON. Natron efflorescens.

Carbonate of Soda.

140. *Primary form:* an oblique rhombic prism; P : M=71° 17′, M : M=76° 12′. It generally occurs in efflorescent crusts.

H.=1—1·5. G.=1·423. *Lustre* vitreous—earthy. *Streak* white. *Color* white; sometimes gray or yellow, owing to the presence of foreign ingredients. *Taste* alkaline.

Composition according to Beudant,

	From Debrezin.	From Egypt.
Carbonate of Soda,	73·6	74·7
Water,	13·8	13·5
Sulphate of Soda,	10·4	7·5
Chlorid of Sodium,	2·2	3·1
Earthy matter,	—	1·4

A strong effervescence takes place on the application of nitric acid. When exposed to the air, natron effloresces, giving out its water of crystallization.

Obs. It occurs at Debrezin, in Hungary, according to Klaproth, (Beitrage, iii. 83,) and also at Montenuovo, near Naples. It is obtained in larger quantities from the soda lakes of Egypt. Other localities exist in Asia and South America.

TRONA. NATRON PERMANENS.

Sesquicarbonate of Soda.

141. *Primary form:* a right rhomboidal prism; M : T=103° 15′. Often occurs in fibrous masses consisting of a congeries of minute crystals.

H.=2·5—3. G.=2·11. *Lustre* vitreous, glistening. *Color* gray, or yellowish-white. Translucent. *Taste* alkaline. Not altered by exposure to a dry atmosphere.

The composition, as determined by Klaproth, (Beitrage, iii. 80,) is as follows. Carbonic Acid 38, Soda 37, Water 22·5, Sulphate of Soda 2·5=100.

OBS. To this species belongs the urao, found at the bottom of a lake in Maracaibo, a day's journey from Merida, in South America. The specimen analyzed by Klaproth, came from the province of Suckenna, two days' journey from Fezzan, Africa. It is found at the foot of a mountain, and forms a crust, varying from the thickness of an inch to that of the back of a knife.

COMMON SALT. SAL CUBICUM.

Hexahedral Rock Salt, *M.* and *J.* Rock Salt. Muriate of Soda, *P.* Chlorid of Sodium. Naturlich Kochsalz, *W.* Steinsalz, *L.* Soude Muriatée, *H.* Sal cubicum, *Wern.* Sal gemmae.

142. *Primary form:* the cube. *Secondaries:* figs. 2, 3, 4, 5, 7, 10, Pl. I. *Cleavage* parallel with the primary faces. *Imperfect crystallizations:* massive. *Structure* columnar, or granular.

H.=2. G.=2·257. *Lustre* vitreous. *Streak* white. *Color* white, also sometimes yellowish, and reddish or bluish; often colorless. Transparent—translucent *Fracture* conchoidal. Rather brittle. *Taste* purely saline.

It consists essentially of Chlorid of Sodium, (Chlorine 59·5, and Sodium 40·5,) but is commonly mixed with small portions of Sulphate of Lime, Chlorid of Calcium, and Chlorid of Magnesium.

It dissolves readily in three times its weight of water. It attracts moisture, but is unchanged in a dry atmosphere. When heated, it usually decrepitates with violence, owing to the water between the laminæ. The native rock salt, containing no water, fuses at a red heat without decrepitation.

OBS. Common salt usually occurs in extensive but irregular beds in secondary rocks, associated with gypsum, polyhalite, clay, sandstone, and calcareous spar; also dissolved, and forming salt springs.

The principal mines of Europe are at Wieliczka, in Poland, those of the Salzkammergat, in Upper Austria; Ischil, Hallein, in Salzburg; Hall, in the Tyrol; Bex, in Switzerland; and Northwich, in Cheshire. At the latter place it occurs in a basin-shaped deposit, and is arranged in spheroidal masses, from 5 to 8 feet in diameter, which are composed of concentric coats, and present polygonal figures. It is but little contaminated with impurities, and is prepared for use by merely crushing it between iron rollers. At the Austrian mines, where it contains much clay, the salt is dissolved in large chambers, and the clay thus precipitated. After ten days or a fortnight, the water, fully saturated with the salt, is conveyed by aqueducts to evaporating houses, and the chambers, after being cleared out, are again filled.

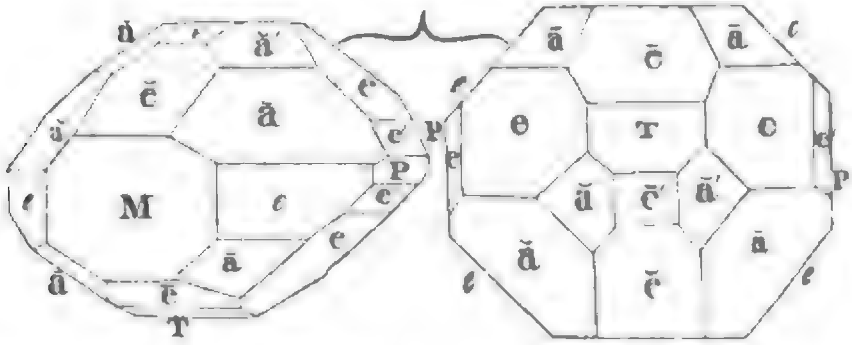
It also occurs in the sandy regions of Africa and Persia, where it has resulted from the evaporation of salt water. A beautiful pure white variety now fills Lake Mareotis, near Alexandria, Egypt; at a distance it resembles a bank of snow.

In the United States it has been observed only in solution, forming salt springs. The most famous of these springs are at Salina, in N. Y., and in the Kenawha and Muskingum Vallies, Ohio, and in Kentucky. There are besides numerous other deposits of it. It invariably arises from the red marl or red sandstone, and is mostly associated with gypsum. The salt water is obtained by boring, and raised by means of machinery, and thence conveyed by troughs to the boilers, where it is evaporated usually by the direct application of artificial heat; sometimes by the heat of steam, and occasionally by exposure to the heat of the sun. The Kenawha brine affords about a bushel of salt from 70 gallons of the liquid.

The various uses of salt are too well known to require enumeration.

GLAUBER'S SALT. Picralum Glauberium.

143. *Primary form:* an oblique rhombic prism. *Secondary form:*



Occurs in efflorescent crusts.

H.=1·5—2. G.=1·481. *Lustre* vitreous. *Color* white. Transparent—opaque. *Taste* cool, then feebly saline and bitter.

Its composition according to the analysis of Reuss, is, Sulphate of Soda 67·024, Carbonate of Soda 16·333, Chlorid of Sodium 11·000, Chlorid of Calcium, 5·643=100·000.

Obs. A few of its localities are, the Sandwich Islands, Ischel and Halstadt, in Austria: it also occurs in Hungary, Switzerland, Italy, Spain, &c.

The artificial salt was first discovered by a German chemist by the name of Glauber, and hence its name.

THENARDITE. Picralum Thenardianum.

144. ***Primary form:*** a right rhombic prism, fig. 72, Pl. II., M : M=125.° ***Secondary forms:*** figs. 75, 76, Pl. II. ***Cleavage*** perfect parallel with the primary faces, most so parallel with P.

H.=2—2·5. G.=2·73. ***Lustre*** vitreous. ***Color*** white. Translucent. Becomes covered with a white powder on exposure to the light.

According to the analysis of M. Casaseca, (Am. de Ch. et de Ph. xxxii. 311,) it is composed of Anhydrous Sulphate of Soda 99·78, and Carbonate of Soda 0·22. It is wholly soluble in water.

Obs. The only known locality of this mineral is Espartine, in Spain, a place 5 leagues from Madrid, and 2½ from Aranjuez. The water exudes from the bottom of a basin during winter, and becoming concentrated in the summer season, deposits crystals of Thenardite.

EPSOM SALT. Picralum rhombicum.

145. *Primary form:* a right rhombic prism; M : M=90° 38′, fig. 72. Pl. II. *Secondary forms:* fig. 75, Pl. II., the planes e being enlarged, and the acute lateral edges also replaced. Other crystals have, in addition, the obtuse lateral edges truncated. *Cleavage* perfect parallel with ĕ. *Imperfect crystallizations:* botryoidal masses and delicately fibrous crusts.

H.=2·25. G.=1·751. *Lustre* vitreous—earthy. *Streak* and *Color* white. Transparent—translucent. *Taste* bitter and saline.

It is composed, according to Vogel, of Sulphuric Acid 33, Magnesia 18, Water 48.

It deliquesces before the blowpipe, but is difficultly fusible before the water of crystallization is driven off. It is very soluble in water. It does not effervesce with the acids.

Obs. This salt is a frequent ingredient in mineral waters, and also occurs often as efflorescences on rocks. In the former state it exists at Epsom, whose springs have long been famous. This place, originally named Ebshamus, gave the name to this salt. At Idria, in Carniola, it occurs in silky fibres, and hence has received the denomination, by the workmen, of Hairsalt. It is also obtained in the gypsum quarries of Montmartre, near Paris, at Arragon, in Spain, in the Cordillera of St. Juan, in Chili, and in a grotto in Southern Africa, where it forms a layer 1½ inches thick. The salt from this last locality was analyzed by Stromeyer, and found to contain Sulphate of Magnesia 42·654, Sulphate of Manganese 07·667, Water 49·243 =99·564. The roof of the grotto is a quartzose conglomerate, containing manganese and pyrites.

The limestone caves of Kentucky and Indiana have their floors, in many instances, covered with Epsom salt, in minute crystals, mingled in with the earth. It effloresces from the calcareous sandstone, ten miles from Coeymans, on the east face of the Heidelberg, N. Y.

REUSSITE. Picralum Reussii.

146. *Primary form:* probably a right rhombic prism. It is said to occur in flat six sided prisms, also in acicular crystals; but usually, it appears in the state of a loose mealy efflorescence.

Color snow-white. *Taste* saline and bitter.

According to Reuss, it is composed of

Sulphate of Soda	66·04
Sulphate of Magnesia	31·35
Chlorid of Magnesium	2·19
Sulphate of Lime	0·42=100·00

Soluble in water.

Obs. It is found in the neighborhood of Sedlitz.

MASCAGNINE. Picralum volcanicum.

147. In mealy crusts and stalactitic forms.

Lustre of crystallized mascagnine, vitreous. *Color* yellowish-grey, lemon-yellow. Translucent. *Taste* pungent and bitter.

This mineral has not been analyzed. It is, probably, a nearly pure Sulphate of Ammonia. It dissolves readily in water.

It occurs about volcanoes, in the fissures of the lava; more particularly at Etna, Vesuvius, and the Lipari Isles.

APHTHITALITE. PICRALUM VESUVIANUM.

148. *Primary form* of artificial crystals, right rhombic prisms; M : M=112° 8′, *a* : *a*=106° 46′. It has been observed in nature only in a massive state, presenting imperfectly mammillary forms, which are sometimes composed of concentric coats.

H.=2—3. G.=1·731. *Lustre* vitreous. *Color* white, sometimes tinged with blue or green. Translucent. *Taste* saline and bitter, disagreeable.

It fuses readily before the blowpipe, without intumescence. It effervesces strongly with sulphuric acid.

OBS. Its only known locality is Vesuvius, where it occurs upon the lava in masses, often an inch or more in thickness.

SAL-AMMONIAC. PICRALUM OCTAHEDRUM.

Octahedral Ammoniac Salt, ***M.*** **Muriate of Ammonia,** ***P.*** **Naturlicher Salmiak,** ***W.*** **Salmiak,** ***L.*** **Ammoniaque Muriatée,** ***H.***

149. *Primary form:* the regular octahedron. *Secondaries:* figs. 1 and 16, Pl. I. *Cleavage* parallel with the faces of the octahedron. *Imperfect crystallizations:* stalactitic and globular masses; in crusts, or as an efflorescence.

H.=1·5—2. G.=1·528. *Lustre* vitreous. *Streak* white. *Color* white; often yellowish or greyish. Translucent—opaque. *Fracture* conchoidal. *Taste* saline and pungent.

According to Klaproth, it contains

	Vesuvius.	Bucharia.
Muriate of Ammonia	99·5	97·50
Sulphate of Ammonia	0·5	2·50

It dissolves readily in about three times its weight of water; but does not deliquesce. It is completely volatile before the blowpipe, rising in white fumes. Mingled in the pulverized state with quicklime, it gives out the pungent odor of ammonia.

OBS. It occurs in the cracks and fissures of volcanoes, particularly at Etna, the island of Vulcano and Vesuvius. It has been observed in small quantities in the vicinity of ignited coal seams, as at St. Etienne, in France, and also at Newcastle, and in Scotland. It occurs also in Bucharia.

Sal ammoniac has not hitherto been found in nature in sufficient quantities to be obtained for commerce. It is a valuable article in medicine. It is employed by tinmen to prevent the oxydation of metallic surfaces, undergoing the operation of tinning or soldering.

The ἅλς ἀμμωνιακός, sal-ammoniac of Dioscorides, Celsus, and Pliny, is fully proved by Beckmann, (Hist. of Inventions, IV, 360,) to be common rock salt. It is described by Pliny as a native salt, dug in Egypt, near the oracle of Ammon, whence its name; this name was afterwards transferred to the muriate of ammonia, when, subsequently, it was manufactured in Egypt. Sal-ammoniac is not supposed to have been entirely unknown to the ancients, but to be described, in connection with one or two other species, under the name of *nitrum*, which, according to Pliny, gave the test of ammonia when mingled with quicklime. (See Moore's Ancient Mineralogy, p. 96.)

NITRATE OF MAGNESIA. Picralum deliquescens.

150. In deliquescent efflorescences. *Color* white.

It consists of Nitric Acid 72, and Magnesia 28. Very deliquescent.

Obs. Occurs in limestone caverns with the nitrate of lime.

NITRATE OF LIME. Picralum tenellum.

151. In efflorescent silken tufts and masses. *Color* white or gray.

It contains Lime 32, Nitric Acid 57·44, and Water 10·56. On burning coals it slowly fuses with a slight detonation, and dries. Very deliquescent before, but not after being desiccated by heat.

Obs. It occurs in silky efflorescences, in the limestone caverns of Kentucky. It is employed in the manufacture of salt petre.

NITRATE OF SODA. Nitrum rhombohedrum.

152. *Primary form:* a rhombohedron; R : R=106° 33′. *Cleavage* perfect parallel to R. Found usually in a state of efflorescence. H.=1·5—2. G.=2·0964. *Lustre* vitreous. *Streak* and *Color* white. Transparent. Rather sectile. *Fracture* indistinctly conchoidal. *Taste* cooling.

Its constituents are Nitric Acid 54·97, and Soda 45·03.

It deflagrates on charcoal with less violence than nitre, producing a yellow light. It dissolves in three parts of water at 60° F. Friction excites negative electricity in its crystals when isolated.

Obs. There is a large deposit of this salt in the district of Tarapaca, near the northern frontier of Chili, constituting a bed of several feet in thickness, which covers an extent of forty leagues in length. Nests of common salt are scattered through it, and also small quantities of nitrate of potash.

Large quantities have been transported to Europe, and in Great Britain it has been introduced into some manufactures as a substitute for nitre. On account of its deliquescing, it is unfit for the manufacture of gunpowder.

NITRE. Nitrum rhombicum.

Nitrate of Potash.

153. *Primary form:* a right rhombic prism; M : M about 120°. The artificial crystals usually have the acute lateral edges truncated, and the acute solid angles deeply replaced. Occurs generally in thin crusts, and delicate acicular crystallizations.

H.=1. G.=1·936. *Lustre* vitreous. *Streak* and *Color* white. Subtransparent. Brittle. *Taste* saline and cooling.

Its composition according to Klaproth's analysis of an African specimen, (Beitrage, iii. 80.) is as follows :—

Nitrate of Potash	42·55
Sulphate of Lime	25·46
Chlorid of Calcium	0·20
Carbonate of Lime	30·40=98·60.

A vivid deflagration takes place on burning coals, and with combustible substances a strong detonation is produced. It dissolves easily in water, and is not altered by exposure.

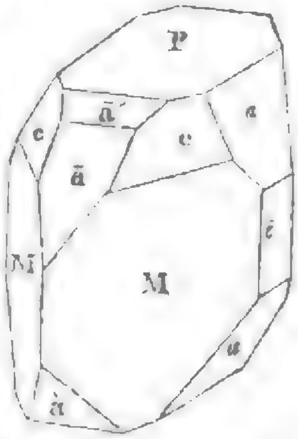
Obs. This salt is found generally in minute needle-form crystals, and crusts on the surface of the earth, on walls, rocks, &c.

Its most abundant locality is India, where it is obtained in large quantities for the arts. It occurs also in Spain, Hungary, Egypt, Persia, &c. In Madison county, Kentucky, it is found scattered through the loose earth, covering the bottom of a large cave. Other similar caverns in the western states of this country, also contain it.

Nitre constitutes about 75 per cent. in the composition of gunpowder, and is principally employed in the manufacture of this substance. In India, it is used for preparing a cooling mixture ; an ounce of powdered nitre in five ounces of water, reduces the temperature, 15° F.

COPPERAS. Vitriolum Martiale.

Green Vitriol. Hemi-prismatic Vitriol-salt, *M.* Sulphate of Iron.



154. *Primary form :* an acute oblique rhombic prism ; M : M=82° 21′, P : M=80° 40′, or 99° 23′. *Secondary form :* e : e=101° 35′, M : ē=138° 50′. ā : e=140° 48′. *Cleavage* perfect, parallel to P ; less so parallel to M. Surface generally smooth. Rare in distinct crystals ; generally massive and pulverulent.

H.=2. G.=1·832, of a specimen containing about 0·1 of sulphate of copper. *Lustre* vitreous, both on the natural surface and the surface of fracture. *Streak* white. *Color* various shades of green, passing into white ; becomes yellowish on exposure. Subtransparent—translucent. *Taste* sweetish, astringent, and metallic. *Fracture* conchoidal. Brittle.

According to Berzelius, it consists of Oxyd of Iron 2·57, Sulphuric Acid 28·9, Water 25·4.

The action of the blowpipe renders it magnetic ; with borax it yields a green glass. It is soluble in twice its weight of water, and the solution is blackened by a tincture of nut galls. On exposure, it is soon covered with a yellow powder, which is the sulphate of the peroxyd of iron.

Obs. This salt usually proceeds from the decomposition of iron pyrites, which readily affords it, if occasionally moistened while exposed to the atmosphere. The old mine of Rammelsburg, near Goslar, in the Hartz, is its most noted locality : it has also been found in aluminous shale at Hurlet, near Paisley, and in several of the Saxon and Hungarian mines.

It is employed in the process of dyeing ; also in the manufacture of ink and Prussian blue.

WHITE COPPERAS. Vitriolum hexagonum.

Bisulphated Peroxyd of Iron, ***Thom.***

155. *Primary form:* a hexagonal prism. The prisms usually have their terminal edges deeply replaced. P : e (a plane replacing the terminal edge; see fig. 125, Pl. II.) =151°, M : e=119°, e : e= 128° 8′. *Cleavage* imperfect, parallel to M. It also occurs in fine granular masses.

Color white; sometimes with a pale violet tint.

Its composition, as determined by M. H. Rose, (Poggend. Annalen, xxvii. 310,) is as follows:

Sulphuric Acid	43·55
Peroxyd of Iron	24·11
Water	30·10
Alumina	0·92
Lime	0·73
Magnesia	0·32
Silica	0·31 = 100.4.

This salt is wholly soluble in cold water: if the solution be heated, peroxyd of iron is copiously precipitated. Dilute muriatic acid dissolves the whole, except a portion of silica.

Obs. It forms a bed in a feldsparry rock, which is supposed to be a fine grained granite, in the province of Coquimbo, the most northerly part of the republic of Chili, about half a days' journey from Copiapo. This salt is probably derived from the decomposition of iron pyrites. The bed of salt is continually on the increase. Pits twenty feet deep have been formed in it by the people of the country.

YELLOW COPPERAS. Vitriolum parasiticum.

Sulphated Peroxyd of Iron, ***Thom.***

156. In small grains, sometimes consisting of delicate hexagonal tables, too minute for the determination of their angles. Easily cleavable parallel to P.

Lustre pearly. *Color* yellow. Translucent.

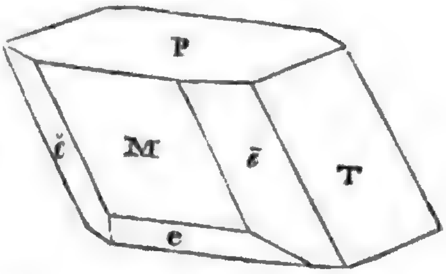
According to the analysis of H. Rose, (Pogg. Ann. xxvii. 314,) it is composed of

Sulphuric Acid	39·60
Peroxyd of Iron	26·11
Water	29·67
Magnesia	2·64
Alumina	1·95
Silica	1·37=101·34.

Obs. It is found incrusting the Chili vitriol, or white copperas, in the district of Copiapo, a province of Coquimbo.

BLUE VITRIOL. Vitriolum Cyprium.

Tetarto-prismatic Vitriol-salt, *M.* Sulphate of Copper.



157. *Primary form:* an oblique rhomboidal prism; P : M=109° 32′, P : T=128° 27′, M : T=149° 2′. *Cleavage* very imperfect. Occurs also amorphous.

H.=2·25. G.=2·213. *Lustre* vitreous. *Streak* white. *Color* deep sky-blue, of different shades. Subtransparent—translucent. *Taste* metallic and nauseous. Somewhat brittle.

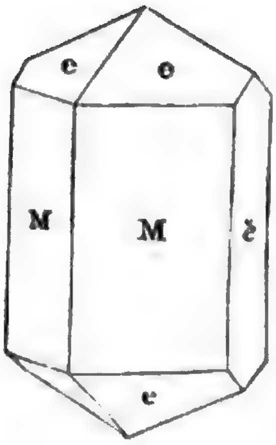
Its constituents are Sulphuric Acid 31·57, Oxyd of Copper 32·13, Water 36·30. It is soluble in water. A polished plate of iron introduced into the solution, becomes covered with copper.

Obs. Blue vitriol is found in waters issuing from mines, and in connection with rocks containing copper pyrites, by the decomposition of which it is formed. Its foreign localities are the Rammelsberg mine, near Goslar, in the Hartz, Fahlun, in Sweden, also Anglesea, and Wicklow.

When purified, it is employed in dyeing operations, and in the printing of cotton and linen, and for various other purposes in the arts.

WHITE VITRIOL. Vitriolum Zincicum.

Prismatic Vitriol-salt, *M.* Sulphate of Zinc.



158. *Primary form:* right rhombic prism; M : M=90° 42′. *Secondary form:* M : e=129° 2′. M : ĕ=134° 38′. *Cleavage* perfect parallel to ĕ, or the shorter of the diagonals of the prism.

H.=2—2·5. G.=2·036, as determined by Haidinger. *Lustre* vitreous. *Color* white. Transparent—translucent. Brittle. *Taste* astringent, metallic, and very nauseous.

Its constituents, according to an analysis by Klaproth, (Beitrage, v. 193,) are,

Oxyd of Zinc	27·5
Sulphuric Acid	20·0
Water	50·0
Oxyd of Manganese	0·5=98.0

It froths under the blowpipe, gives off its sulphuric acid, and covers the charcoal with a white coating of oxyd of zinc. It is easy soluble in water.

Obs. This salt is supposed to be formed by the decomposition of blende. It occurs at the Rammelsburg mine, in the Hartz, at Schemnitz, in Hungary, at Fahlun, in Sweden, and at Holywell, in Wales. It is of rare occurrence in nature.

It is manufactured for the arts, and is very extensively employed in medicine and dyeing. A fine white color, *zinc white*, superior in its durability to white lead, is prepared from it.

COBALT VITRIOL. Vitriolum Cobalticum.

Red Vitriol. Sulphate of Cobalt.

159. In stalactites and crusts, investing other minerals. *Lustre* vitreous. *Color* flesh and rose-red. Subtransparent—translucent. Friable. *Taste* astringent.

The analysis of Kopp, (Gehlen's Jour. 2d series, vi. 157,) gives for its composition, Sulphuric Acid 19·74, Protoxyd of Cobalt 38·71, Water 41·55.

It communicates a blue color to glass of borax.

Obs. It occurs in the rubbish of old mines at Bieber, near Hanau, and also at Leogang, in Saltzburg.

JOHANNITE. Vitriolum Uranicum.

Sulphate of the Protoxyd of Uranium, *Thomson*.

160. *Primary form:* an oblique rhombic prism; crystals flattened and from one to three lines in length, arranged in concentric druses.

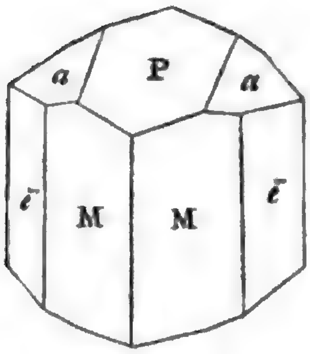
Lustre vitreous. *Streak* yellowish-green. *Color* beautiful emerald-green, sometimes passing into apple-green. Transparent—translucent; sometimes opaque. *Taste* bitter, rather than astringent.

Soluble in water. Solution precipitated chesnut-brown by prussiate of potash, yellowish-green by alkalies, and in brown flocks by an infusion of nutgalls.

Obs. This mineral was discovered by John, in Elias mine, near Joachimstahl, in Bohemia.

BOTRYOGEN. Vitriolum bicolor.

Native Red Iron Vitriol of Fahlun, *Haid*.



161. *Primary form:* an oblique rhombic prism; M : M=119° 56′. *Secondary form:* M : ĕ′=160° 54′, ĕ′ : ĕ′=99° 16′, *a* : *a*=141°. P: *a*=160° 30′. Faces M and ĕ′ striated parallel to the vertical axis. *Cleavage* parallel to M. The crystals are usually small and aggregated in reniform and botryoidal shapes, consisting of globules with a crystalline surface. From this peculiarity in its structure its name is derived.

H.=2—2·5. G.=2·039. *Lustre* vitreous. *Streak* ochre-yellow and a little shining. *Color* deep hyacinth-red; the massive varieties sometimes ochre-yellow. Translucent. *Taste* slightly astringent.

The analysis of Berzelius gives for its composition, Sulphate of Iron 48·3, Sulphate of Magnesia 20·8, Water 30·9.

Under the blowpipe it intumesces and gives off water, producing a reddish-yellow earth, which by using alternately the reduction and oxydizing flame, is changed into protoxyd or peroxyd of iron. With salt of phosphorus, a red glass is produced, which loses its color on cooling. It remains unaltered if kept dry, but when exposed to a moist atmosphere it becomes covered with a dirty yellowish powder. Boiling water dissolves only a part of it, leaving a yellow ochreous residue.

Obs. The only known locality of this mineral is the famous copper mine of Fahlun, in Sweden, where it coats gypsum or pyrites.

GLAUBERITE. Gæalum obliquum.

Hemi-prismatic Brythine-Salt, *Haid.* Brongniartin, *J.* and *P.*

162. *Primary form:* an acute oblique rhombic prism; M : M=83° 20′, P : M=104° 15′. *Secondary forms:* similar to fig. 101, Pl. II.; another variety has the front lateral edge ĕ truncated; P : ē=137° 9′, ē : ē=116° 20′, M : ĕ=131° 40′. *Cleavage* perfect parallel to P.

H.=2·5—3. G.=2·75—2·85. *Lustre* vitreous. *Streak* white. *Color* pale-yellow, or gray. *Fracture* conchoidal; brittle. *Taste* slightly saline.

It contains Sulphate of Lime 49, and Sulphate of Soda 51. Immersed in water it loses its transparency, and is partly dissolved. On long exposure it absorbs moisture and falls to pieces. Under the action of the blowpipe it decrepitates and melts into a white enamel. If insulated, resinous electricity may be excited by friction.

Obs. It occurs in crystals in rock salt at Villa Rubia, near Ocana, in New Castile, and also at Aussee, in Upper Austria.

POLYHALITE. Gæalum columnare.

Bloedite, *John.*

163. *Primary form:* a right rhombic prism; M : M=115°. It seldom occurs distinctly crystallized, but usually in fibrous masses.

H.=2·5—3. G.=2·7689. *Lustre* resinous, or slightly pearly. *Streak* red. *Color* flesh or brick-red, sometimes yellowish. Translucent—opaque. *Taste* bitter and astringent, but very weak.

Stromeyer determined the composition of a specimen from Ischel to be as follows:

Anhydrous Sulphate of Lime	22·2184
Anhydrous Sulphate of Potash	27·6347
Anhydrous Sulphate of Magnesia	20·0347
Hydrous Sulphate of Lime	28·4580
Anhydrous Sulphate of Iron	0·2927
Chlorid of Sodium	0·1910
Chlorid of Magnesium	0·0100
Peroxyd of Iron	0·1920

According to the analysis of Berthier, three varieties from Vic are constituted as follows:

	Crystallized.	Red massive.	Gray massive.
Sulphate of Lime	40·0	45·0	40·0
Sulphate of Soda	37·6	44·6	29·4
Chlorid of Sodium	15·4	6·4	0·7
Sulphate of Magnesia	0·0	0·0	17·6
Sulphate of Manganese	0·5	0·0	0·0
Alumina and Oxyd of Iron	4·5	3·0	4·3
Loss	2·0	1·0	8·0

Becomes opaque in the flame of a candle, and of a brownish color. Under the blowpipe it fuses instantaneously. It is but slightly soluble in water.

Obs. The mines of Ischel and Aussee, in Salzburg, where it occurs with common salt, gypsum, and anhydrite, and the salt mines of Vic, in Lorraine, are the principal localities of this mineral.

The name, Polyhalite, is derived from πολύς, many, and ἅλς, salt, in allusion to the number of salts in its constitution.

CLASS II. ENTOGÆA.

ORDER II. HALINEA.

OXALATE OF LIME. Astasialus phytogeneus.

Humboldtine. Eisen Resin *Breithaupt.*

164. Earthy; crystallization undetermined.

G.=2·13—2·489. Soft; may be scratched by the nail. Dull.

Color yellow. *Fracture* uneven, earthy. Acquires negative electricity by friction, when insulated.

Its constituents, according to Mariano de Rivero, are Oxalic Acid 46·14, and Protoxyd of Iron 53·86.

It blackens in the flame of a candle instantly, and then is attractable by the magnet. A continuance of the heat causes the evolution of a vegetable odor, and soon decomposes it, leaving a stain, at first yellow, then black, and finally red.

Obs. It occurs at Koloseruk, in Bohemia, and, according to the supposition of Rivero, has resulted from the decomposition of succulent plants.

CRYOLITE. Cryalus fusilis.

Prismatic Cyrone-Haloid, *M.* Alumine Fluatée Alcaline, *H.*

165. *Primary form:* a right rectangular prism. *Cleavage* parallel to P perfect, parallel to the lateral faces less so. Occurs in lamellar masses.

H.=2·25—2·5. G.=2·949. *Lustre* vitreous; slightly pearly on P. *Streak* white. *Color* white; sometimes reddish or brownish. Subtransparent—translucent. Immersion in water increases its transparency. Brittle.

The analysis of Berzelius, (Kong. Vet. Acad. Handl. 1823, p. 315,) shows it to be composed of Alumina 24·4, Soda 31·35, and Hydrofluoric Acid 44·25. It is fusible in the flame of a candle, and hence its name, from κρυος, *ice*. Before the blowpipe, it first fuses, then becomes hard, white, and opaque, and ultimately assumes a slaggy appearance.

Obs. Arksutfiord, in West Greenland, is the only known locality of this mineral. It was discovered by Giesècké, in two veins in gneiss, associated with galena, pyrites, and spathic iron. Specimens may there be obtained from six inches to a foot in diameter.

ALUM STONE. Aluminus rhombohedrus.

Rhombohedral Alum Haloide, *M.* Alumine Sous-sulfatée Alcaline, *H.*

166. *Primary form:* an obtuse rhombohedron; R : R=92° 50′. *Secondary form:* fig. 113, Pl. II. *Cleavage* nearly perfect parallel to a; indistinct parallel to R. It also occurs massive, having a granular or impalpable composition.

H=5. G.=2·58—2·752. *Lustre* vitreous on R, inclining to pearly on a. *Streak* white. *Color* white, sometimes grayish or reddish. Transparent—subtranslucent. *Fracture* flat, conchoidal, uneven; of massive varieties, splintery, and sometimes earthy. Brittle.

The analyses of Vauquelin and Cordier, give the following composition:

	From Mont d'Or, in Auvergne.	From Tolfa.
Sulphuric Acid	27·05	25·00
Alumina	31·80	43·92
Silica	28·40	24·00
Potash	5·79	3·08
Water and loss,	3·72, Cordier.	4·00, Vanquelin.

It decrepitates in the blowpipe flame, and is infusible both alone and with soda. With borax, it forms a colorless globule. When pulverized, it is soluble in sulphuric acid.

Obs. This mineral is met with in crystals at Tolfa, near Civita Vecchia, in the neighborhood of Rome; also at Beregh, in Hungary. It occurs only in volcanic rocks. The compact varieties from Hungary are so hard, as to admit of being used for millstones. Alum is obtained from this mineral by repeatedly roasting and lixiviating, and, finally, crystallizing by evaporation.

FLUELLITE. Fluellus pyramidalis.

Fluate of Alumina. Fluorid of Aluminum.

167. *Primary form:* a right rhombic prism; M : M=105° nearly. It commonly appears under the form of an acute rhombic octahedron, fig. 76, Pl. II., in which a : a=109°

Color white. Transparent.

Contains Fluoric Acid and Alumina, according to an imperfect analysis by Wollaston.

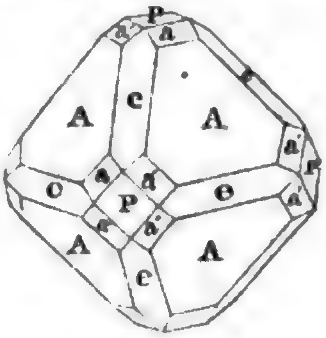
Obs. Fluellite is an extremely rare mineral, and was first discovered by Levy. The few specimens that have been obtained, were found at Stenna-gwyn, in Cornwall, with Wavellite and uranite, in minute crystals, on quartz.

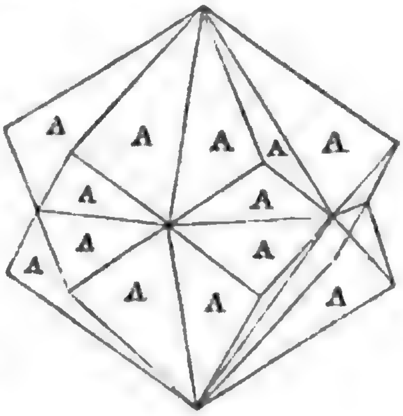
I hesitate somewhat in connecting this species in the same genus with fluor spar, &c. If a new genus should be instituted, it would have its place between Cryalus and Fluellus.

FLUOR SPAR. Fluellus octahedrus.

Fluate of Lime. Fluorid of Calcium. Ratoffkit. Chlorophane. Octahedral Fluor-Haloide, *M.* Chaux Fluatée, *H.* Muria Phosphorans, *Linn.*

168. *Primary form:* the regular octahedron, fig. 4, Pl. I. *Secondary forms:* form of the most common occurrence is the cube, fig. 1, Pl. II. Some of its other forms are represented in figures 2, 3, 5, 6, 7, 9, 10, 11, 14, 16, 24, and 25, of the same plate. These simple forms also occur in combination, as in the annexed figure. *Cleavage* obtained with facility parallel to A. *Compound crystals:* fig. 129, Pl. II.; also the annexed figure, which is an instance of the same kind of composition; but the individuals are continued beyond the face of composition, and one is partially enveloped by the other. *Imperfect crystallizations:* structure rarely columnar; often granular, particles of various sizes.





H.=4. G.=3·14—3·178. *Lustre* vitreous; sometimes splendent; usually glimmering of the massive impalpable varieties. *Streak* white. *Color* white, wine-yellow, emerald-, pistachio-, bluish-green, rose and crimson-red, violet-blue, and sky-blue. Wine-yellow and violet-blue are the most common; and the red varieties the rarest. The colors of massive varieties are often arranged in concentric lines; and occasionally in crystals they are arranged along the axes, or in concentric coats. Transparent—subtranslucent. Brittle. *Fracture* of massive impalpable varieties, flat, conchoidal, and splintery.

It is composed of Fluorine 47·37, and Calcium 52·63.

Below a red heat, the coarsely pulverized spar becomes vividly phosphorescent. The colors of the light thus produced are very various, and are independent of the external color. The variety chlorophane emits a bright emerald-green light. At a high temperature, phosphorescence ceases. The passage of the electric fluid through it, is said to restore this property. Under the blowpipe, fluor spar decrepitates, and ultimately fuses into an enamel. If the flame be continued, the fluorine is in part expelled, and the specimen assumes a cauliflower-like appearance.

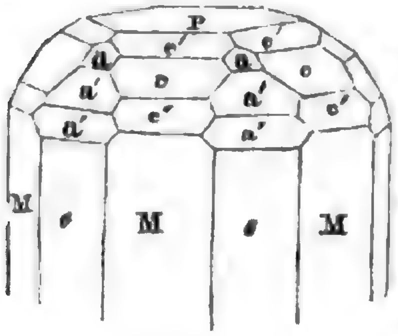
Obs. Fluor spar seldom occurs in beds in rocks. It generally constitutes veins, and in this state occurs in great abundance in the north of England, where it is the gangue of the lead mines, which intersect the coal formations of Northumberland, Cumberland, Durham, and Yorkshire. In Derbyshire, also, it is very abundant; and also in Cornwall, where the veins intersect much older rocks. In the mining districts of Saxony, it is a common mineral.

The most remarkable locality of fluor spar in the United States, has been discovered within a few years, on the borders of Muscalonge lake, in St. Lawrence county, New York, where it occurs in cavities in granite. Cubical crystals of an enormous size, some, more than a foot in each of their dimensions, have been obtained at this place. The spar of this region has usually an emerald or bluish-green color. In Gallatin county, Illinois, in the region southwest of Caves rock, for thirty miles along the Ohio, at Shawneetown and other places, this mineral is found scattered through the soil or imbedded in limestone. The prevailing color is a dark purple. Large crystals are often obtained at this locality.

The chlorophane variety forms a vein in gneiss, in the town of Trumbull, Conn., where it is associated with topaz and magnetic pyrites. It seldom occurs in distinct crystals, but commonly in coarsely granular masses of a light reddish or reddish-gray color. At the Notch of the White mountains, in New Hampshire, green octahedrons have been observed in a crystalline quartz. The mica slate at Putney, Vermont, also contains a green variety, in small quantities. It also occurs, sparingly, in Shenandoah county, Virginia, near Woodstock, in the fissures of a limestone containing shells; also on the Potomac, at Shepardstown, in white limestone; in Smith county, Tennessee, in white and purple cubes; at Lockport, in white cubes in a black limestone, accompanying celestine; in Massachusetts, at the Southampton mine; near the Franklin furnace, New Jersey; at Amity, New York, in thin seams, associated with hornblende, spinel, and turmaline.

APATITE. Fluellus hexagonus.

Rhombohedral Fluor-Haloide, *M.* Phosphate of Lime. Spargelstein, Phosphorit, *W.* Asparagus stone. Moroxite. Chrysolite.



169. *Primary form:* a hexagonal prism, fig. 114, Pl. II. *Secondary forms:* fig. 125, Pl. II., also the annexed figure.

P : e=139° 48′, P : e′=157° 6′, P : e″=120° 36′, M : e=130° 12′, M : e′=112° 54′, M : e″=149° 24′, P : a=143° 48′, P : a′=124° 20′, P : a″=108° 51′, *e* : a=126° 12′, *e* : a′=145° 40′, *e* : a″=161° 9′. *Cleavage* imperfect, parallel both to P and M. *Imperfect crystallizations:* globular and reniform shapes; structure imperfectly columnar: massive, structure granular.

H.=5, sometimes 4·5. G.=3—3·235. *Lustre* vitreous, inclining to subresinous. *Streak* white. *Color* usually sea-green, bluish-green or violet-blue; sometimes white; also occasionally yellow, gray, red, and brown; none bright. Transparent—opaque. A bluish opalescence is observed in the direction of the vertical axis in some specimens, especially in the white varieties. Cross *fracture* conchoidal and uneven. Brittle. Some varieties are *phosphorescent* when heated, particularly those crystals which are but slightly modified at their extremities; others become electric by friction.

The following table contains several analyses of G. Rose, (Poggendorf's Annalen, ix.)

	Snorum, Norway.	Cabo de Gata, Spain.	Arendal, Norway.	Greiner, Tyrol.	St. Gothard, Tyrol.
Chlorid of Calcium	4·28	0·885	0·801	0·15	a trace.
Fluorid of Calcium	4·59	7·049	7·01	7·69	7·69
Subsesquiphosphate of Lime	91·13	92·066	92·189	92·16	92·31
	G.=3·174	G.=2·35	G.=3·194	G.=3·175	G.=3·197

It is infusible alone before the blowpipe except at the edges. With biphosphate of soda or borax, it fuses without difficulty into a glass, which, on cooling, has a crystalline structure. It also fuses if mixed with carbonate of iron. It dissolves slowly in nitric acid, and without effervescence.

Obs. Apatite usually occurs in primitive formations. It is often found in veins, and particularly those containing tin and iron ore, also, in veins of primitive limestone traversing granite. It also occurs in serpentine, and occasionally, as in Spain, in ancient volcanic rocks.

Its principal foreign localities are Ehrenfriedersdorf, in Saxony; Slackenwald, in Bohemia; Caldbeck Fell, in Cumberland, Devonshire; St. Gothard, in Switzerland. The greenish-blue variety, called *moroxite*, occurs at Arendal, in Norway.

The *asparagus stone* or *spargelstein* variety, which is obtained at Zillerthal, in the Tyrol, is translucent and has a wine-yellow color; it is imbedded in talc. The *phosphorite* or massive varieties, are mostly obtained from Estremadura, in Spain, and Slackenwald, in Bohemia.

Its most important locality in the United States, is at Gouverneur, St. Lawrence Co., N. Y., where it occurs in a vein of limestone, intersecting granite, and within a foot or two of the granite: the crystals are most abundant near the junction of the two rocks. Crystals have been obtained at this locality, six inches long and one and a half in diameter, possessing a fine sea-green color, and variously modified at their extremities. It is associated with finely crystallized scapolite and sphene, and a purplish or brown pyroxene. At Amity, N. Y., it occurs of a green color in white limestone, presenting the primary form, and is accompanied with pyroxene and scapolite. Crystallized and massive specimens, of a bluish-green color, occur at Bolton, Mass., associated with sphene, petalite, and also the minerals occurring at the abovementioned localities. Reddish-brown crystals of an inch in length, have been obtained from a vein of granite, at Greenfield, N. Y. Also, it has been found near Baltimore, Md.; Wilmington, Del.; Green Pond, Morris Co., N. Y.; and at Anthony's Nose, in the Highlands on the Hudson.

Apatite was thus named by Werner, from απαταω, *to deceive*, in allusion to the deception of the older mineralogists, respecting the nature of its several varieties.

WAGNERITE. Fluellus obliquus.

Hemi-prismatic Fluor-Haloide, *Haid.* Wagnerit, *Fuchs.* Fluophosphate of Magnesia, *Thom.*

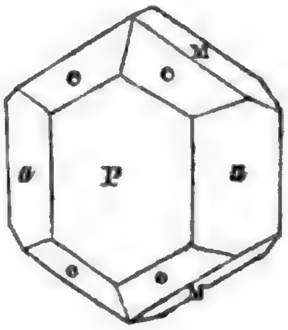
170. *Primary form:* an oblique rhombic prism; M : M=95° 25′. P : M=109° 20′. Most of the prismatic planes are deeply striated, H.=5—5·5. G.=3·11. *Lustre* vitreous. *Streak* white. *Color* yellow, of different shades; often grayish. Translucent. *Fracture* uneven and splintery across the prism.

It contains, according to Fuchs, Phosphoric Acid 41·71, Hydrofluoric Acid 6·50, Magnesia 46·66, Oxyd of Iron 5, Oxyd of Manganese 0·5. It fuses with difficulty, *per se*, before the blowpipe, into a dark greenish-gray glass: with borax or biphosphate of soda, it is readily dissolved. Nitric or sulphuric acid, gently heated, evolves from its powder fumes of fluoric acid.

Obs. This rare species occurs in the valley of Holgraben, near Werfen, in Saltzburg, in irregular veins of quartz, traversing clay slate.

HERDERITE. Fluellus rhombicus.

Prismatic Fluor-Haloide, *Haid.* Brewster's Journal, IX, 360.

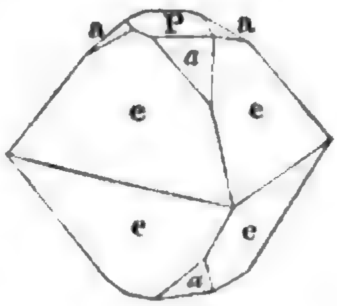


171. *Primary form:* a right rhombic prism; M : M=115° 53′. *Secondary form:* P : *a*= 147° 34′, *a* : *a*, (adjacent planes,) 64° 51′, e : e= 144° 16′, M : e=128° 40′, P : e=141° 20′. *Cleavage* interrupted parallel to M, also traces parallel to P. Surfaces M and e very smooth, and delicately marked with lines parallel to their edges of intersection with M.

H.=5. G=2·985. *Lustre* vitreous, inclining to subresinous. *Streak* white. *Color* various shades of yellowish and greenish-white. Translucent. *Fracture* small conchoidal. Very brittle.

Obs. The only specimen of this mineral as yet found, was obtained at the tin mines of Ehrenfriedersdorf, in Saxony, imbedded in fluor spar. It much resembles the asparagus variety of apatite, for which it was mistaken till proved to be a distinct species by Haidinger, who gave it the above name in compliment to Baron Von Herder, the director of the Saxon mines.

CHILDRENITE. Fluellus Childrenii.



172. *Primary form:* trimetric. *Secondary form:* e : e (adjacent planes in the same pyramid,) =97° 50′ and 102° 30′, e : e (different pyramids,) =130° 20′, a : a=124° 54′. *Cleavage* imperfect, parallel with P.

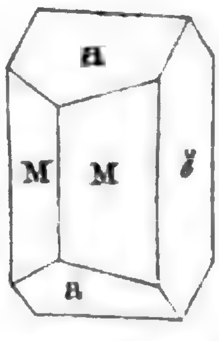
H.=4·5—5. *Lustre* vitreous, inclining to resinous. *Streak* white. *Color* yellow, and pale yellowish-brown, also yellowish-white. Translucent. *Fracture* uneven.

It is composed, according to Wollaston, of Phosphoric Acid, Alumina and Iron.

Obs. Occurs in minute crystals and crystalline coats, on spathic iron or quartz, near Lavistock, in Derbyshire. It was discovered by Levy, and named in honor of Mr. Children.

WAVELLITE. Astralus rhombicus.

Prismatic Wavelline-Haloide, *Haid.* Subphosphate of Alumine. Devonite. Hydrargyrite. Lasionite.



173. *Primary form:* a right rhombic prism; M : M=122° 15′. *Secondary form:* a : a (adjacent planes,) =107° 26′, M : ĕ=118° 53′. *Cleavage* perfect parallel to M, and also to ĕ or the longer diagonal. It usually occurs in minute crystals radiating from a point, and so closely aggregated as to form hemispherical or globular concretions. These concretions vary from a minute size, to an inch or more in diameter.

H.=3·25—4. G.=2·337—2·3616. *Lustre* vitreous, inclining to pearly and resinous. *Streak* white. *Color* white, passing into yellow, green, gray, brown, black. Translucent.

It consists of

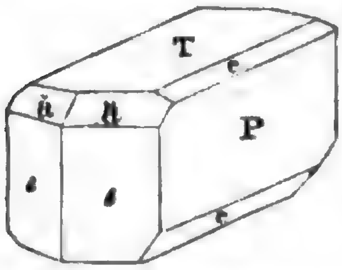
Alumina	37·20	35·35
Phosphoric Acid	35·12	33·40
Water	28·00	26·80
Fluoric Acid	0·00	2·06
Lime	0·00	0·50
Oxyd of Iron and Manganese	0·00=100·32 *Fuchs.*	1·25=99·36 *Berzelius.*

Becomes white under the blowpipe, losing its translucency, but is infusible. With boracic acid and iron wire, it affords a globule of phosphuret of iron. Reduced to powder, it dissolves in heated nitric or sulphuric acid, giving off a vapor which corrodes glass.

Obs. Wavellite was first discovered in a tender clay slate near Barnstaple, in Devonshire, by Dr. Wavell. It has since been found at Clommell, near Cork, in the Shiant isles of Scotland; at Zbirow, in Bohemia; on brown iron ore at Amberg, in Bavaria, (a variety called *Lasionite*, by Fuchs.)

PHARMACOLITE. GYPSALUS STELLATUS.

Hemi-prismatic Euclase-Haloide, *Haid.* Arsenate of Lime. Arsenic bluth, *Werner.* Picropharmacolite.



174. *Primary form:* a right rhomboidal prism, whose oblique angle equals 96° 46′. *Secondary form:* T : M (plane truncating the edge *e* : *e*)=83° 14′, and 96° 46′; *e* : *e*=117° 24′; P : *e*=121° 18′. *Cleavage* parallel to T eminent. The crystals are usually lengthened in the direction of P, and often one face *e* is obliterated by the extension of the other; in these instances the crystal is attached to the rock parallel to the extended *e*, and receives its increase of attraction in the direction of this axis. (See § 81.) The surfaces T and e are usually striated parallel to their mutual intersection. Occurs rarely in distinct crystals; commonly in delicate silky fibres or acicular crystallizations, aggregated in stellated groups. It also presents botryoidal and stalactitic shapes, and sometimes its composition is impalpable.

H.=2—2·5. G.=2·64—2·73. *Lustre* vitreous, except on P, on which it inclines to pearly. *Streak* white. *Color* white or grayish; frequently tinged red by the arsenate of cobalt which often accompanies it. Translucent—opaque. *Fracture* uneven.

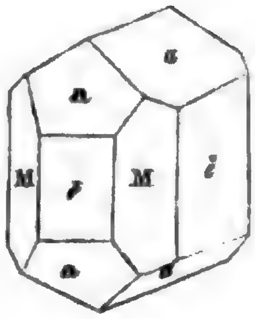
According to Klaproth, a specimen from Wittichen, (Beitrage, iii. 277,) contained Lime 25, Arsenic Acid 50·54, Water 24·46. John's analysis of a specimen from Andreasberg, gives Lime 27·28, Arsenic Acid 45·68, Water 23·86. Pure specimens from Mr. Ferguson's collection were analyzed by Dr. Turner, and found to contain Arsenate of Lime 79·01, and Water 20·99. Exposed to the blowpipe it is almost entirely volatilized, and gives off dense white fumes of arsenic. It dissolves readily in nitric acid without effervescence.

Obs. Crystals of pharmacolite have been found in the grand-duchy of Baden: also in botryoidal or globular groups of delicate white silky crystals at St. Marie aux Mines in the Vosges, at Andreasberg in the Hartz, and at Riegelsdorf, in Hessia; at Wittichen, near Furstenberg in Germany, it occurs in acicular crystals associated with cobalt, and disseminated on granite.

The picropharmacolite, from Riegelsdorf, differs from the above species, according to Stromeyer, (Untersuchungen, p. 135,) merely in containing about three per cent. of magnesia.

HAIDINGERITE. Gypsalus rhombicus.

Diatomous Gypsum-Haloide, *Haid.* Brewster's Journal, Vol. III. p. 303.



175. *Primary form:* a right rhombic prism; M : M=100°. *Secondary form:* M : c̄=140°, M : ĕ=130°, *a* : *a* (adjacent planes,)=126° 58′, ĕ : *a*=116° 31′. *Cleavage* highly perfect and easily obtained, parallel to ĕ.

H.=1·5—2·5. G.=2·848. *Lustre* vitreous. *Streak* white. *Color* white. Transparent—translucent. Sectile; thin laminæ slightly flexible.

According to Turner, it is composed of Arsenate of Lime 85·681, and Water 14·319. Dissolves easily in nitric acid.

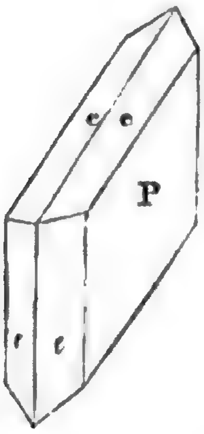
Obs. This mineral was first distinguished as a species by Mr. Haidinger. A single specimen only has been obtained from its locality at Baden. It is associated with pharmacolite, of which it was supposed to be a variety; it occurs mostly in minute crystals, aggregated into botryoidal forms.

GYPSUM. Gypsalus rhomboideus.

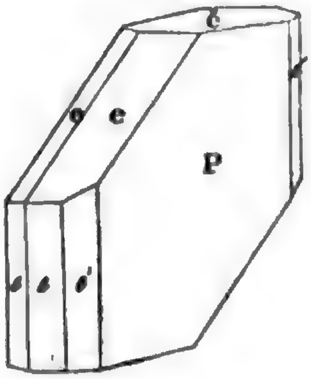
Prismatoidal Gypsum-Haloide, *M.* Sulphate of Lime. Alabaster. Selenite. Gypseus vulgaris, *Cartheuser.* Γύψος.

176. *Primary form:* a right rhomboidal prism; M : T=113° 18′. *Secondary forms:*

1.



2.



P : e=108° 34′, e : e=142° 52′, P : *e*=124° 42′, P : *e*′=134° 21. *Cleavage* highly eminent, parallel to P; parallel to M much less perfect, parallel to T obtained with difficulty on account of the flexibility of the mineral in this direction. *Compound crystals:* composition of the *first kind* parallel to each of the three primary faces. The arrow-shaped crystals result from a composition parallel to T. Crystals of gypsum vary from an enormous size to delicate acicular fibres. *Imperfect crystallizations:* stellated aggregations, composed of sublamellar particles; also lamellar and granular; sometimes nearly impalpable.

H.=1·5—2. G.=2·31—2·3257. *Lustre* of P pearly and shining, of M and T vitreous. Massive varieties have often a glistening lustre, and sometimes are dull and earthy. *Streak* white. *Color* usually white, sometimes gray, flesh-red, honey-yellow, ochre-yellow, and blue: in pure varieties are often black, brown-red, or reddish-brown. Transparent—opaque. Brittle parallel to M.

Gypsum is composed of Sulphuric Acid 44·8, Lime 33·0, and Water 21·0. Before the blowpipe it becomes opaque and of a white color, exfoliates, and falls to a powder. At a high heat it fuses with difficulty into a white enamel. The white powder obtained by heat, if moistened, soon becomes very firmly solid. It does not effervesce with acids when pure.

Obs. The transparent varieties have been distinguished by the name *Selenite*; and the fine massive varieties are called *Alabaster*. Gypsum often forms very extensive beds in secondary countries, and is usually found in connection with the new red sandstone. It also occurs in clay, and in coal formations; and sparingly in several rock strata besides the sandstone: it is also a product of volcanoes.

The finest foreign specimens are found in the salt mines of Bex, in Switzerland; at Hall, in the Tyrol; in the sulphur mines of Sicily; in the gypsum formation, near Ocana, in Spain; and in the clay of Shotover Hill, near Oxford. Large lenticular crystals have been met with at Montmartre, near Paris. Derbyshire produces the fibrous varieties. Near Sienna, in Tuscany, it occurs extremely pure and compact. It is transported from this place to Florence, and there employed for the manufacture of vases, figures, &c. It also occurs in acicular crystals covering lavas.

This species occurs in extensive beds in several of the United States; and more particularly New York, Ohio, Illinois, Virginia, Tennessee, and Arkansas, and is usually associated with salt springs.

Transparent crystals, of the form in fig. 1, have been found at Poland, and Canfield, Trumbull Co. Ohio. Beautiful specimens of the selenite variety occur near Lockport, N. Y., associated with calcareous spar in scalene dodecahedrons, and rhombohedral crystals of brown spar.

The value of gypsum in the arts, depends principally on the property it possesses of hardening, when moistened after having been heated. It is used for making moulds, taking casts of statues, medals, &c., for producing a hard finish on walls; also in the manufacture of artificial marbles, as the scagliola tables of Leghorn; it is also ground up and employed for improving lands.

The fibrous variety when cut *en cabochon*, and polished, reflects light similarly to cat's eye.

This mineral is easily distinguished from mica by its inferior hardness and want of elasticity, and by the inferior facility of its cleavage; and, in general, its softness will distinguish it from the minerals it most resembles.

ANHYDRITE. Gypsalus rectangulus.

Prismatic Gypsum-Haloide, *M.* Cube Spar, Muriacite, *W.* Karstenite *Haus.* Vulpinite.

177. *Primary form:* a right rectangular prism. *Secondary form:* similar to fig. 70, Pl. II. $\bar{M} : e$=140° 4′. *Cleavage* nearly equally perfect parallel to $\breve{M}$ and $\bar{M}$, less so parallel to P. *Imperfect crystallizations:* structure fibrous, lamellar, or granular, and sometimes impalpable. The lamellar and fibrous particles are often variously contorted.

H.=2·75—3·5. G.=2·899—2.957. *Lustre* somewhat pearly, parallel to $\bar{M}$ and $\breve{M}$; vitreous parallel to P; and in the imperfectly crystallized varieties, vitreous inclining to pearly. *Streak* grayish-white. *Color* white, sometimes with a grayish, bluish, or reddish tint; also brick-red. *Fracture* uneven; of finely lamellar and fibrous varieties, splintery.

It is composed, according to Klaproth, of Lime 41·75, Sulphuric Acid 55·0, and Chlorid of Sodium 1·0.

It whitens under the blowpipe, but does not exfoliate like gypsum, and finally is covered with a friable enamel. With borax, it dissolves with effervescence into a transparent glass, becoming yellow, or brownish-yellow, on cooling.

Anhydrite sometimes attracts moisture, and assumes an appearance somewhat resembling gypsum. It is, however, readily distinguished by its cleavage.

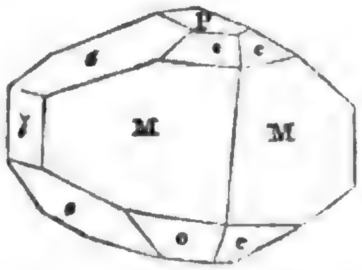
Obs. Anhydrite has been variously denominated muriacite, anhydrite, tripe stone, (gekrösstein,) according to its structure; the first, when crystallized in broad lamellæ; the second, when granular; and the third, when composed of contorted particles. Fine specimens of the crystalline variety occur at the salt mines of Bex, in Switzerland; and at Hall, in the Tyrol. At Aussee, both the crystalline and massive varieties occur; the latter of a brick-red color. It is also found at Sultz, on the Neckar; at Bleiberg, in Carinthia; at Ischil, in Upper Austria; and at Berchtesgaden, in Bavaria: the variety *gekrösstein* has been found principally at Wieliczka, in Poland. The *Vulpinite*, from Vulpino, Italy, is harder than the other varieties, and admits of being cut and polished for ornamental purposes.

In the United States, it has been found at Lockport, N. Y., of a fine blue color, in geodes of black limestone, accompanied with crystals of calcareous spar and gypsum. The decomposed variety has also been observed at the same place, forming a thin incrustation on the foliated variety, and also between the foliæ.

ROSELITE. Gypsalus Cobalticus.

178. *Primary form:* a right rhombic prism; M : M = 132° 48′. *Secondary form:* the annexed figure. *Cleavage* distinct and brilliant, parallel to ĕ. Twin crystals are of common occurrence.

H.=3. *Lustre* vitreous. *Streak* white. *Color* deep rose-red. Translucent.



According to an imperfect analysis by Children, it contains Oxyd of Cobalt, Lime, Arsenic Acid, Magnesia, and Water. Before the blowpipe, it parts with its water of crystallization, and becomes black. With borax and salt of phosphorus, it yields a blue globule.

Obs. Its only known locality is at Schneeberg, in Saxony, where it has been found in small quantities on quartz. It resembles cobalt-bloom in color, and was at first mistaken for it. Its distinctive characters, particularly crystallographic, were observed by Levy, who named the mineral after the distinguished Dr. Gustavus Rose, of Berlin.

HYDROBORACITE. Gypsalus fusilis.

Hydrous Calcareo-biborate of Magnesia, *Thom.*

179. Resembles fibrous and foliated gypsum.

H.=2. G.=1·9. *Color* white, with spots of red from iron. Thin plates translucent.

It contains, according to Mr. Hess,

Boracic Acid	49·922	49·22
Lime	13.298	13·74
Magnesia	10·430	10·71
Water	26·330=99·98.	26·33=100.

Fusible under the blowpipe.

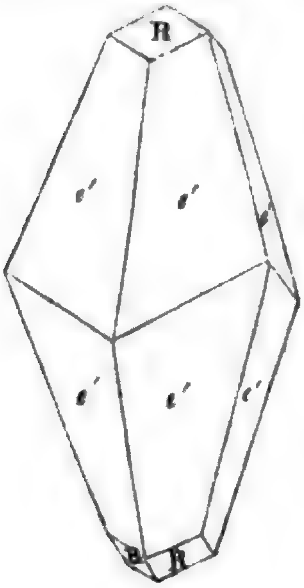
Obs. It was observed by Mr. Hess, in a collection of Caucasian minerals. The specimen was full of holes, filled with clay, containing different salts. It has been mistaken for gypsum; but it is readily distinguished by its easy fusibility.

CALCAREOUS SPAR. Calcius rhombohedrus.

Rhombohedral Lime-Haloide, *M.* Carbonate of Lime. Marl, Agaric Mineral, Anthraconite, Aphrite, Argentine, Chalk, Inolite, Marble, Oolite, Ostreocolla, Peastone, Pisolite, Slate Spar, Travertine, Tufa.

180. *Primary form:* an obtuse rhombohedron; R : R=105° 5'. *Secondary forms:* figures from 109 to 122, Pl. II.; also the annexed figures, of which fig. 2 has been observed at Derbyshire.

1



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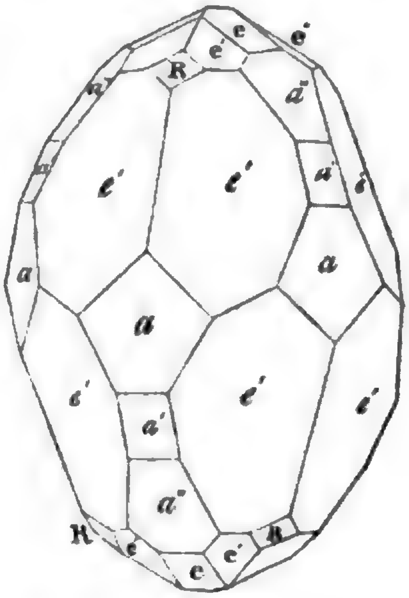

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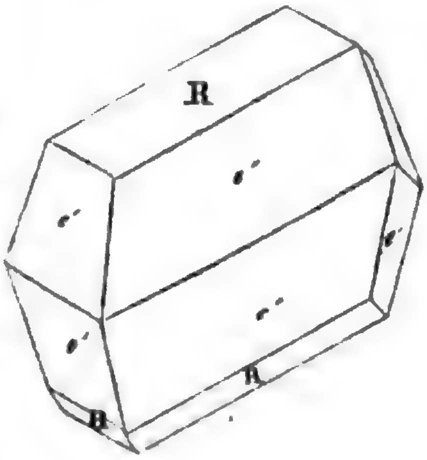
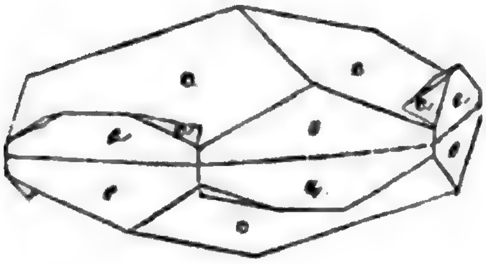


R : *e*'=150° 58' 16". *e*' : *e*'=132° 58'. R : *a*=134° 36'. R : e=142° 32'. e : e=134° 57'. e : *a*=116° 15'. Several rhombohedrons of different angles, formed on the lateral angles of the primary, occur in nature. That which is commenced by the planes *a*', in fig. 121, Pl. II., and when completed, resembles fig. 122, has its interfacial angles *a*' : *a*'=78° 5'. Another, still more acute, is occasionally observed, the inclination of whose faces equals 65° 50'; and another of 60° 36'. Fig. 3 is a distorted scalene dodecahedron, from Rossie, St. Lawrence Co., N. Y. The lettering of its planes will explain its relation to the primary rhombohedron, and the scalene dodecahedron represented in fig. 1. *Cleavage* highly perfect, parallel to the primary faces R. *Compound crystals:* fig. 16, Pl. III. This form has been already remarked upon, § 75. Fig. 4 is an instance of a similar kind of composition. The faces e are formed by a truncation of the terminal edges, fig. 119, Pl. II. The peculiar appearance of this compound crystal arises from the extension of each form beyond the face of composition. This crystal is from Alstonmoor. In fig. 5 the composition is of the same kind, but has taken place between two poles, or axial extremities, of one end of the crystal, and one at the other. *Imperfect crystallizations:* structure fibrous, both coarse and finely delicate; also composed of lamellar particles of various sizes, sometimes so large as to give the rock a slaty structure, at other times granular, coarsely or impalpably; also it presents stalactitic forms, some of immense size, which may be internally massive, fibrous, or perfectly crystalline.

4



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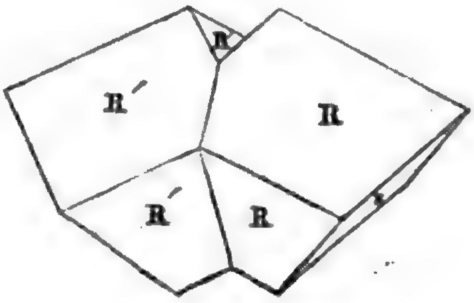


H.=2·5—3·5. G.=2·508—2·778. The purest kinds vary, according to Beudant, from 2·5239—2·7234, (Ann. des Mines, 2d Ser. V. 275.) *Lustre* vitreous—subvitreous—earthy. *Streak* white, or grayish-white. *Color* usually white; also a great variety of shades of gray, red, green, yellow, all pale; also brown and black, when impure. Transparent—opaque. The transparent varieties exhibit very distinctly *double refraction. Fracture* usually conchoidal, but obtained with difficulty, when the specimen is crystalline.

Calcareous Spar is composed of Lime 56·15, and Carbonic Acid 43·7, according to Stromeyer's analysis; 55·5, and 44·0, according to Phillips. The colored varieties often contain, in addition, small portions of iron, silica, magnesia, alumina, bitumen, &c. Acids produce a brisk effervescence.

Before the blowpipe, it is infusible; it loses, however, its carbonic acid, gives out an intense light, and ultimately is reduced to pure lime, or *quicklime*.

Obs. Calcareous spar appears under a very great variety of forms and aspects, and, consequently, was distributed by the earlier mineralogists into several distinct species. These now constitute varieties.

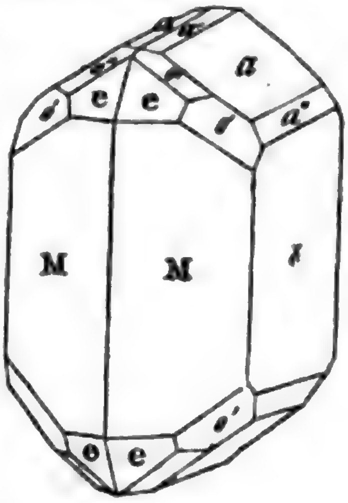
Iceland spar was first applied to a transparent crystallized variety from Iceland, by means of which the property of double refraction was first observed. *Oolite* consists of minute spherical particles, aggregated by a calcareous cement, so as to produce a massive structure, and nearly earthy appearance. It occurs in extensive beds. It is so called from its resemblance to the roe of fish, from ὠὸν, *egg*. The *Peastone*, or *Pisolite*, differs from oolite in the larger size of its particles. These particles are composed of concentric laminæ. *Chalk* is a massive opaque variety, usually white, and possessing a purely earthy aspect, and absence of lustre. It is usually much softer than the other varieties of this species. *Agaric Mineral*, or *Rock Milk*, is a loose friable variety, deposited from waters containing carbonate of lime in solution. It is formed about lakes, whose waters are impregnated with lime; also in fissures in limestone, and in limestone caverns. *Marble* includes all the imperfectly crystalline and earthy varieties which admit of a high polish. The *Stinkstone*, *Swinestone*, or *Anthraconite*, which is found columnar, granular, and compact, of various shades, emits a fetid odor, when struck with the hammer. *Stalactites* are pendent masses of limestone, formed in limestone caverns by the percolation of water, holding lime in solution, through their rocky roofs; the evaporation of the water causes the deposition of the lime; and thus, in time, columns are often formed extending from the roof to the floor of a cavern. The water which drops to the floor from the roof also evaporates, and causes the formation of a layer of limestone over the floor. This variety has been called *Stalagmite*. *Argentine* possesses a silvery white lustre, and contains a little silica. *Marl* is a mixture of clay and carbonate of lime. *Calcareous Tufa* occurs in beds formed by deposition from water, and has a very porous structure. The *Fontainebleau Limestone* is an aggregate of secondary rhombohedrons, containing, mechanically mingled, large portions of sand. This species, in some of its forms, is very generally diffused. England and France contain extensive strata of chalk. Italy, from her Carrara beds, and Greece, from the Pentelican quarries, have provided the world with statuary marble. The greater part of the middle and western sections of the United States are underlaid with strata of limestone.

At Oxbow, St. Lawrence Co., N. Y., crystals, of the form of the scalene dodecahedron, occur, a foot or more in length, in veins of primary limestone. Fine transparent rhombohedrons, of two inches or more in each of their dimensions, are also found in the same region, in connection with veins of lead. The specimens of dogtooth spar, (scalene dodecahedral crystallizations,) from Lockport, N. Y., are often extremely beautiful and delicate. They occur, covering the sides of cavities in limestone. Argentine occurs near Williamsburg and Southampton, Mass.; also in the iron mines of Franconia, N. H. Agaric mineral covers the sides of a cave at Watertown, N. Y., to the thickness of six to twelve inches. Stalactites occur in the celebrated Wier's cave of Virginia, and in the large caves of Kentucky; also in the cave at Scoharie, N. Y., and in many parts of the western states.

Calcareous spar is the principle source of our polished marbles, the material for sculpture, quicklime, flux for smelting ores, &c. A peculiar fine grained, compact variety is employed in lithography; the best for this purpose occurs at Pappenheim, and Sohlenhofer, in Bavaria.

ARRAGONITE. CALCIUS RHOMBICUS.

Prismatic Lime-Haloide, *M.* Eisenbluth, *W.* Igloite. Flos-ferri. Needle Spar.



181. *Primary form:* a right rhombic prism; $M:M=116^\circ\ 10'$. *Secondary form:* $M:\breve{e}=121^\circ\ 55'$, $\breve{e}:a=125^\circ\ 50'$, $\breve{e}:a'=109^\circ\ 49'$, $\breve{e}:a''=145^\circ\ 19'$. *Cleavage* parallel with M. *Compound crystals:* similar to the figures 13, Pl. III., and 3, 5, 6, and 11, Pl. IV., which have been described in § 74 and § 76. *Imperfect crystallizations:* globular, reniform, and coralloidal shapes; columnar masses, composed of straight or divergent columns, or fibres of various sizes.

H.=3·5—4. G=2·931, Haidinger, -2·927 Biot. *Lustre* vitreous, sometimes inclining to resinous on surfaces of fracture. *Streak* grayish-white. *Color* white; also passing into gray, yellow, green, and violet-blue. Transparent–translucent. *Fracture* subconchoidal. Brittle. It possesses double refraction, but in a less degree than calcareous spar.

Arragonite, according to Stromeyer, contains

Carbonate of Lime	95·2965	99·2922
Carbonate of Strontia	0·5090	4·1043
Water	0·1544=95·9599.	0·5992=103·9957.

The carbonate of strontian is a very variable ingredient and does not exist in all the varieties. Carbonate of lime is, therefore, one of the dimorphous substances, calc spar being one of its forms, and the rhombic crystals of Arragonite the other. (See remarks on dimorphism, § 83.)

When Arragonite is heated, it parts with its water of crystallization and falls to powder. It is phosphorescent on red hot iron, and is soluble with effervescence in nitric and muriatic acids.

Obs. The most common repositories of Arragonite are beds of gypsum, beds of iron ore, (where it occurs in coralloidal forms, and is denominated flos-ferri, '*flower of iron*,') basalt and trap rocks; occasionally, it occurs in lavas. It is often associated with copper and iron pyrites, galena, and malachite.

This mineral was first discovered at Arragon, in Spain, (whence it derives its name,) in large detached compound crystals, imbedded in a ferruginous clay and accompanied by gypsum. It has since been obtained in fine compound hexagonal prisms at Bilin, in Bohemia, in a vein traversing basalt. The *flos-ferri* variety is found in the greatest perfection in the Styrian mines of Eisenerz, coating cavities and even caves of considerable extent, and associated with spathic iron. At Dufton, the silky fibrous variety called *Satin Spar*, is obtained, where it occurs traversing shale in thin veins, generally associated with pyrites. In Buckinghamshire, Devonshire, &c., it occurs in stalatitic forms in caverns.

The flos-ferri occurs at Lockport, N. Y., coating gypsum in geodes; also at Edenville, N. Y., lining cavities of mispickel and cube ore, and at Haddam, Conn., in thin seams between layers of gneiss. Veins of this mineral occur at Scoharie.

DOLOMITE. Calcius Dolomæi.

Macrotypous Lime-Haloide, *M*. Bitter Spar. Pearl Spar. Magnesian Limestone.

182 *Primary form:* an obtuse rhombohedron; $R:R=106^\circ\ 15'$. *Secondary forms:* the most common are two acute rhombohedrons; in one, $a':a'=79^\circ\ 36'$, from Gotha, in Saxony, in the other, $a'':a''=66^\circ\ 7'$, from Hall, Tyrol. *Cleavage* perfect parallel to R. Faces a' usually with horizontal striæ. *Compound crystals:* similar to fig. 5, § 180, presented by a greenish-white cleavable variety, from Mexico. *Imperfect crystallizations:* imitative shapes; also amorphous, of a granular structure; particles of various sizes, generally easily distinguishable, and often slightly coherent.

H.=3·5—4. G=2·884. *Streak* grayish-white. *Lustre* vitreous, inclining to pearly in some varieties. *Color* white, seldom pure, usually reddish or greenish; also rose-red, green, brown, gray, black. Subtransparent to translucent. Brittle.

Composed, according to Klaproth, of Carbonate of Lime 54·18, and Carbonate of Magnesia 45·82.

This species is soluble in the acids, but more slowly than calcareous spar. Before the blowpipe, some varieties darken and increase in hardness.

Obs. The names *Rhomb spar* and *Bitter spar*, have been applied to the perfectly crystallized specimens, excepting those with curved faces and a pearly lustre, which have been designated *Pearl spar*. Those varieties of rhomb spar of a reddish-brown color, have also been named *Brown spar* The name, Dolomite, has been restricted to the imperfectly crystallized varieties of a granular structure.

The Dolomite variety occurs in beds; rhomb spar usually in imbedded crystals; brown spar commonly in metalliferous veins. Dolomite occurs at Traversella, in Piedmont, and at St. Gothard, in the Appenines. Rhomb spar is found in Salzburg, the Tyrol, Miemo, in Tuscany, from which the name *Miemite* was derived. Brown spar and pearl spar are obtained at Schemnitz, in Hungary, Kapnik, in Transylvania, at Freiburg, in Saxony, in the lead mines of Alston, in Derbyshire, and at other places in Devonshire.

Roxbury, Vt., affords large yellow transparent crystals of the rhomb spar variety, imbedded in greenish-transparent talc. A large grained cleavable variety, occasionally presenting perfect crystals, is associated with white talc in calcareous spar, at Smithfield, R. I. The pearl spar variety is very abundant in geodes at Lockport, N. Y., accompanying calcareous spar, celestine, and gypsum. Massive Dolomite forms extensive beds in Litchfield Co., Conn., in the south-western towns of Massachusetts, and in Vermont. The gray-wackes and secondary limestones in various places in New York and Ohio, contain brown spar in veins and seams.

For agricultural purposes Dolomite is inferior to calcareous spar, the magnesia it contains being injurious to the soil. For the formation of mortar it is highly valued, it being less subject to disintegration than ordinary mortar. It is also much inferior to common limestone for a building material, on account of its friability or the loose coherence of its particles. This species was named in honor of Dolomieu.

ANKERITE. Calcius decolorans.

Paratomous Lime-Haloide, *M.* Rohe Wand and Wandstein of the Styrian miners.

183. *Primary form:* an obtuse rhombohedron; R : R–106° 12′. *Cleavage* parallel with R. Occurs commonly in easily cleavable masses; also of a compact granular composition, in which the grains are distinctly discernible.

H.=3·5—4. G.=2·95—3.1. *Lustre* vitreous. *Streak* white. *Color* white, sometimes yellowish or brownish from an admixture of iron. Translucent—subtranslucent. *Fracture* uneven.

Its constituents, according to Schrötter's analysis, are

Carbonic Acid with Oxyd of Iron	35·308
Lime	50·113
Magnesia	11·846
Oxyd of Manganese	3·084=100·351.

Before the blowpipe it blackens, and then will act upon the magnetic needle, but is infusible. A pearly globule is formed with borax. Exposure to the air darkens its surface.

Obs. This species occurs at Rathhausberg and Salzburg; also at the Styrian mines of Eisenerz, where it is valued both as an iron ore and a flux.

The transition limestone about Quebec contains it in veins, and at West Springfield, Mass., it occurs in connection with the coal formation.

It was first distinguished as a distinct species by Mohs, who named it after Prof. Anker, of the Johanneum, in Gratz.

CARBONATE OF LIME AND SODA.

Ann. of Phil. May, 1830.

184. *Primary form:* a rhombohedron. Occurs massive—structure laminated. *Cleavage* parallel to the faces of a rhombohedron.

H.=3—3·5. G.=2·92. *Lustre* vitreous, resembling Arragonite. Fragments perfectly transparent. Possesses double refraction.

It contains Carbonate of Lime 70, Carbonate of Soda 14, Water 9·7, Peroxyd of Iron 1·0, besides 5·0 of matrix. It decrepitates slightly before the blowpipe, becomes brown, and finally affords lime. It dissolves with effervescence in nitric acid.

OBS. Locality unknown.

RHOMB SPAR. MAGNESIALUS RHOMBOHEDRUS.

Brachytypous Lime-Haloide, *M.* Bitter Spar, in part. Dolomite, in part. Breunnerite. Carbonate of Magnesia and Iron.

185. *Primary form:* an obtuse rhombohedron; R : R=107° 22′. *Cleavage* eminent parallel to R. Imperfectly crystalline varieties occur, having a compact granular composition.

H.=4—4·5. G.=3·001—3·112. *Lustre* vitreous, inclining to pearly in some varieties. *Streak* grayish-white. *Color* white, commonly yellowish, or brownish. Transparent—translucent. *Fracture* subconchoidal. Brittle.

It contains Carbonate of Magnesia and Carbonate of Iron, in the ratio of 86·85 to 13·15, according to Brooke. It turns brown on exposure, or under the blowpipe.

OBS. Its foreign localities are Salzburg, the Tyrol, and Switzerland. It occurs at Marlborough, Vermont, in steatite, at Middlefield, Mass., and in most of the soapstone quarries of New England.

MAGNESITE. MAGNESIALUS FIBROSUS.

Baudisserite. Carbonate of Magnesia. Razoumuffskin.

186. Amorphous, reniform, also in crusts. Composed occasionally of delicate diverging fibres, possessing a silky lustre: usually having an impalpable composition, and sometimes earthy.

H. of earthy varieties, sometimes as low as 2. The compact magnesite varies from 3 to 4. G. of earthy varieties, 1·2—2·6, of the compact 2·808—2·95.

Lustre earthy, dull, sometimes silky. *Streak* white. *Color* white—yellowish-white, or gray. Opaque. *Fracture* flat conchoidal.

Its constituents are, according to

	Klaproth; Sp. from Steyermark.	Stromeyer; Sp. from Baumgarten.
Magnesia	48·00	47·6334
Carbonic Acid	49·00	50·7512
Water	3·00	1·4037
Ox. Mang.	—— =100.	0·2117=100.

It dissolves slowly, with little effervescence, in nitric, or dilute sulphuric acid, and is infusible before the blowpipe.

Obs. This species occurs at Hrubschitz, in Moravia, at the Gulsen mountains, in Styria, at Baumgarten, in Silesia, at Baudissero, in Piedmont, at Valeccas, in Spain. At Hoboken, N. J., it occupies seams and cavities in Dolomite, and serpentine, having a closely aggregated fibrous structure; also at Bolton, Mass., where it appears in delicate, indistinctly fibrous masses, traversing white limestone.

HYDROMAGNESITE. MAGNESIALUS PULVEREUS.

Hydro-carbonate of Magnesia.

187. Occurs in crusts; also as a white powder. H.=2. *Lustre* earthy. *Streak* and *Color* white.

It contains, according to Wachtmeister and Kobell,

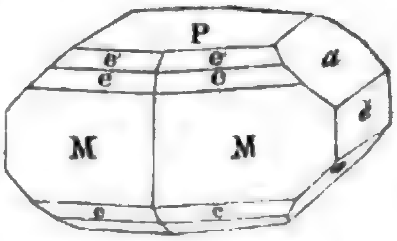
Magnesia	42·41	43·96
Carbonic Acid	36·82	36·00
Water	18·53	19·68
Silica	0·57	0·36
Peroxyd of Iron, and foreign matter	1·66=99·99. W.	—— =100. K.

Obs. It occurs, accompanying magnesite, in India; also in seams and in crusts, coating Arragonite, at Hoboken, N. J. This species is usually united with the preceding, from which it differs merely in the water it contains.

ORDER II. BARYTINEA.

STRONTIANITE. Barytes rubefaciens.

Peritomous Hal-Baryte, *M.* Carbonate of Strontian.



188. *Primary form:* a right rhombic prism; M : M=117° 32′. *Secondary form:* M : ĕ=121° 14′, e′ : e′=108° 12′, e : e′=144° 20′. Simple crystals of this mineral are rare, it usually presenting compound forms, which in general resemble those of Arragonite. The near approximation of the value of the angle M : M, to 120°, accounts for the so frequent occurrence of compound forms, (§ 76.) The surface P is usually striated parallel to the shorter diagonal. *Cleavage* parallel with M nearly perfect; traces parallel to ĕ. *Imperfect crystallizations:* structure often aggregated in columnar globular forms; also fibrous. A granular composition sometimes occurs, but is unfrequent.

H.=3·5—4. G.=3·605—3·713. *Lustre* vitreous, slightly inclining to resinous on uneven faces of fracture. *Streak* white. *Color* asparagus-green, apple-green; also white, gray, yellow, and yellowish-brown. Transparent—translucent. *Fracture* uneven. Brittle.

Klaproth's and Hope's analyses give for its composition,

Strontia	69·5	61·21
Carbonic Acid	30·0	30·20
Water	0·5=100, Klaproth.	8·59=100, Hope.

Thomson found the two varieties from Strontian to contain,

	Green.	Brown.
Carbonate of Strontia	93·49	91·17
Carbonate of Lime	6·28=99·77.	8·64=99·81.

Another variety from the United States, which he has named *Emmonite*, in honor of Prof. Emmons, of Williams College, Mass., contains 12·5 per cent of Carbonate of Lime. These are probably mechanical mixtures.

Nitric and hydrochloric acids dissolve strontianite with effervescence; and paper wet with the solution, and afterwards dried, burns with a red flame. The flame of the blowpipe is also tinged red by it. It melts only on the thinnest edges. In a very strong heat, the carbonic acid and water are expelled. With borax, it effervesces violently, and yields a transparent globule.

Obs. Strontianite was first discovered at Strontian, in Argyleshire, in veins traversing gneiss, with galena and heavy spar. It occurs there in stellated and fibrous groups, rarely perfectly crystallized. Yorkshire and Braunsdorf, in Saxony, are other localities.

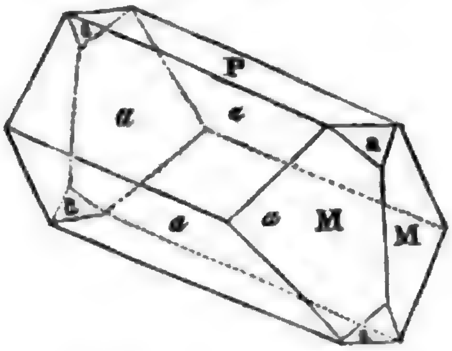
In the United States it occurs at Scoharie, both in granular masses, and also presenting columnar crystallizations or acicular crystals; also in finely terminated crystals of considerable size. It exists there in a secondary limerock, forming veins, and sometimes crystallized in geodes. It is associated with heavy spar, iron pyrites, and crystals of calcareous spar. The massive variety occurs in large quantities.

CELESTINE. Baralus prismaticus.

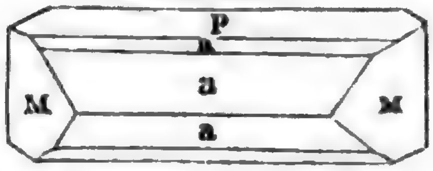
Prismatoidal Hal-Baryte, *M.* Sulphate of Strontian. Zölestine, *Wern.*

189. *Primary form:* a right rhombic prism; M : M=103° 58′. *Secondary forms:*

1. Etna.



2. Lake Erie.



P : *a*=128° 31′, *a* : *a*=102° 58′, P : a=140° 44′, a : a=78° 35′, P : a′=157° 45′, a : a′=162° 59′, Fig. 1 is lengthened in the direction of its shorter lateral axis, and fig. 2 in the direction of the longer. *Cleavage* distinct parallel with M, less so parallel with P. *Imperfect crystallizations:* structure fibrous; also in globular masses of columnar composition. Occasionally it appears granular of various sizes of grains.

H.=3—3·5. G.=3·92—3·963. *Lustre* vitreous, sometimes inclining to pearly. *Streak* white. *Color* generally white, often bluish or reddish. Transparent—subtranslucent. *Fracture* imperfectly conchoidal—uneven. Very brittle.

According to Thomson's analysis, of specimens from Bristol and from Sicily, it is composed of

	Bristol.	Sicily.
Sulphate of Strontia	98·353	98·68
Sulphate of Lime	1·073	1·02
Moisture	0·200	0·30
Silica and Alumina	0·374=100.	—— =100.

Before the blowpipe it decrepitates and fuses into a white friable enamel. Heat destroys its transparency, and causes a phosphorescence of the pulverized mineral.

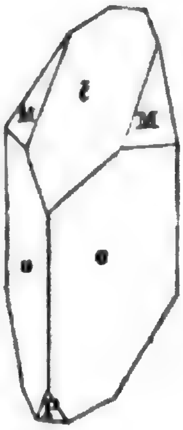
Obs. Celestine is usually associated with secondary, or transition limestone, or secondary sandstone. It also occurs in trap rocks and in beds of gypsum, in which it is often associated with sulphur. Sicily has long been famous for the splendid groups of crystals of this mineral which there occur, accompanied with sulphur and gypsum. Fine specimens are met with also at Bex, in Switzerland, and Conil, in Spain. Fibrous varieties occur of a blue color, in clay, at Dornberg, near Jena. It is also found at Aust Ferry, near Bristol; in trap rocks near Tamtallan, in East Lothian; near Knaresborough, in Yorkshire; at Norton, in Hanover.

Beautiful specimens, finely crystallized, of a bluish tint, are found in great abundance in the secondary limestone about Lake Erie, and particularly on Strontian island, where the rock is full of splendid crystallizations of this species. Scoharie and Lockport, N. Y., also afford fine specimens. At the latter place they are associated with the crystallized calc spar of the region.

Dr. Thomson separates the radiated celestine, found on Drummond island, Lake Erie, and at Kingston, U. C., from the above species. An analysis, performed in his laboratory, gave for its composition, Sulphate of Barytes 35·195, and Sulphate of Strontian 63·204, with a little Iron and Water. Its Hardness he states at 2·75, Specific gravity 3·921; color white, with a bluish tint; structure laminated, laminæ diverging.

BARYTO-CALCITE. Baralus obliquus.

Hemi-prismatic Hal-Baryte, *M.*



190. *Primary form:* an oblique rhombic prism; M : M=106° 54′. P : M=102° 54′. *Secondary form:* o : o=95° 15′. M : ĕ=143° 27′. *Cleavage* perfect parallel with M; less easily effected parallel with P. Occurs also massive.

H.=4. G.=3·6363—3·66. *Lustre* vitreous, inclining to resinous. *Streak* white. *Color* white, grayish, greenish, or yellowish. Transparent—translucent. *Fracture* uneven.

Analyses by Mr. Children and Mr. Richardson determine the following for the constituents of this mineral:

	Children.	Richardson.
Carbonate of Baryta	65·9	62·20
Carbonate of Lime	33·6	31·65
Sulphate of Baryta	——	0·30
Peroxyd of Iron	——	0·85
Water, or volatile matter,	—— =99·5.	3·45=98·45.

Before the blowpipe, it is infusible alone. With borax, or biphosphate of soda, it fuses into a transparent glass. It effervesces with hydrochloric acid.

Obs. It occurs at Alstonmoor, in Cumberland, both massive and crystallized.

Another compound of carbonate of lime and carbonate of barytes, is described by Thomson as a *bicalcareo-carbonate of barytes.*

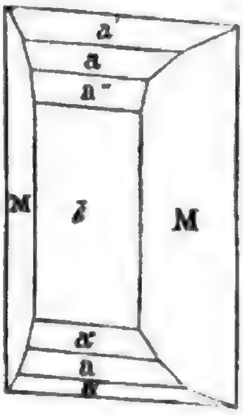
The form presented by the specimen examined, was an isosceles dodecahedron, fig. 124, Pl. II.; the inclination of two adjacent faces in the same pyramid, about 132°. H.=2·25. G.=3·718. *Lustre* vitreous. *Color* snow-white. Translucent, It contained Carbonate of Barytes 49·31. and Carbonate of Lime 50·69, which is equivalent to one atom of the former to two of the latter. The crystals were in groups, implanted upon a white crystalline substance, which appeared to be a heavy spar. Locality unknown.

WITHERITE. Baralus fusilis.

Diprismatic Hal-Baryte, *M.* Carbonate of Barytes Barolite.

191. *Primary form:* a right rhombic prism; M : M=118° 30′. *Secondary form:* M : ē=149° 15′. ē : a″=145° 30′, ē : a=126° 16′, ē : a′=110° 30. *Cleavage* imperfect. *Compound crystals:* composition of the first kind, presenting the form of a hexagonal prism, similar to those of Arragonite. *Imperfect crystallizations:* globular, tuberose, and botryoidal forms; structure either columnar or granular; also amorphous.

H.=3—3·75. G.=4·29—4·30. *Lustre* vitreous, inclining to resinous. *Streak* white. *Color* white, often yellowish, or grayish. Subtransparent—translucent. *Fracture* uneven. Brittle.



Klaproth found the Styrian variety of Witherite, (Beitrage i. 271,) to be composed of Carbonic Acid 2·75, and Baryta 9·50. Bucholz obtained 79·76 of Baryta, and 20 of Carbonic Acid. It decrepitates under the blowpipe, and melts easily into a transparent globule, which becomes opaque on cooling. It dissolves with effervescence in dilute nitric or hydrochloric acids.

Obs. Witherite was first observed at Alstonmoor, in Cumberland, associated with galena, in veins traversing the coal formation. It was described, in 1784, (Phil. Trans. 1784, p. 293,) by Dr. Withering, after whom the mineral was named by Werner. The compact fibrous and translucent variety occurs at Anglezark, in Lancashire. Styria, Hungary, Siberia, and Sicily are mentioned as other localities. But it is only abundant in England.

This mineral is so poisonous, that it is used in the north of England for the purpose of killing rats.

DREELITE. Baralus rhombohedrus.

Dufrénoy, Ann. de Ch. et de Ph. LX. 102.

192. *Primary form:* an obtuse rhombohedron; R : R=93° or 94°. *Cleavage* apparent only in traces.

H.=3·5. G=3·2—3·4. *Lustre* pearly; splendent on a surface of fracture. *Streak* and *Color* white.

It contains, according to Dufrénoy, Sulphate of Baryta 61·701, Sulphate of Lime 14·274, Carbonate of Lime 8·050, Lime in excess 1·521, Silica 9·712, Alumina 2·404, Water 2·308=100.

Obs. It occurs in small unmodified crystals, disseminated on the surface, and in the cavities of a quartzose rock.

It was named by Dufrénoy in compliment to M. de Dree, a liberal patron of science.

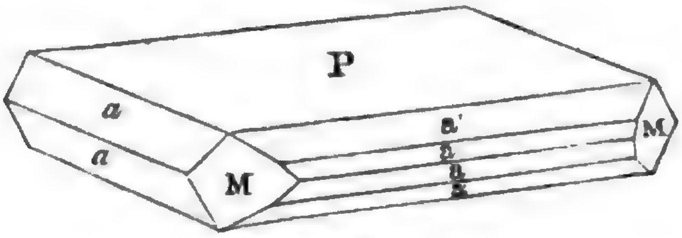
HEAVY SPAR. Baralus ponderosus.

Prismatic Hal-Baryte, *M.* Sulphate of Barytes. Hepatite, *Haus.* Baroselenite. Aerhemsten. Bolognian Spar. Cawk. Litheospore.

193. *Primary form:* a right rhombic prism; M : M=101° 42′.

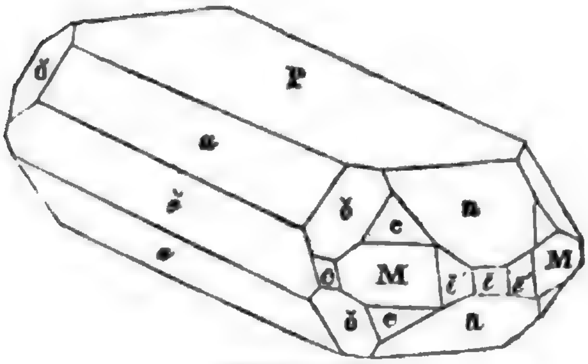
Secondary forms :

1.



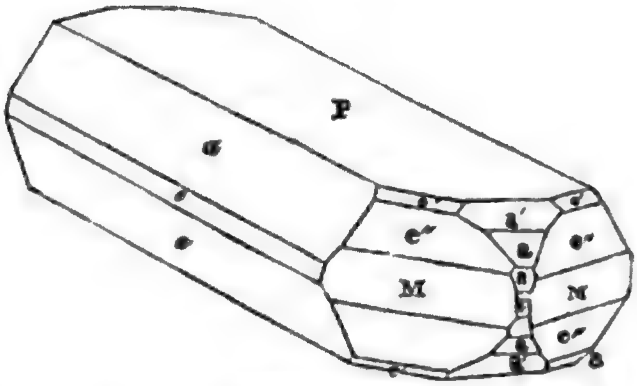
Cheshire, Conn.

2.



Cheshire, Conn.

3.



Cheshire, Conn.

M : *ē*=140° 51′, M : *ĕ*=129° 9′, P : a=141° 11′, P : a′=158° 2′, P : a″=121° 48′, P : e′=165° 26′, P : e″=115° 41′, P : *a*=127° 18′, *a* : ĕ=142° 42′, M : e′=154° 19′. *Cleavage* P and M perfect. *Imperfect crystallizations:* globular forms, with a columnar or lamellar composition ; broad coarse laminæ, often slightly diverging and curved ; impalpably granular forms, sometimes possessing the banded colors of stalagmite.

H.=2·5—3·5. G=4·3—4·72 ; the latter was obtained by Thomson, with a transparent colorless crystal. *Lustre* vitreous, inclining to resinous, sometimes pearly. *Streak* white. *Color* white ; also inclining to yellow, gray, blue, red, or brown. Transparent to translucent—opaque.

Pure specimens are composed of Sulphuric Acid 34, and Baryta 66. Oxyd of Iron, Silica, Carbonate of Lime, and Alumina, occur sometimes as impurities in specimens of this mineral. Under the action of the blowpipe it decrepitates, and is difficultly fusible. Some specimens loose their color when heated.

Obs. Heavy Spar occurs commonly in connection with beds or veins of metallic ores. It is also met with in secondary limestones, sometimes forming distinct veins, at others, in crystals, along with crystallizations of lime and strontian.

The most noted English locality is at Dufton, where large transparent crystals occur. In Mr. Allan's cabinet there is one crystal from this locality of a tabular form, which weighs forty-two pounds, and whose face P measures ten inches across.

Some of the most important European repositories of this mineral, are at Felsobanya and Cremnitz, in Hungary; Roya and Roure, in Auvergne. At Freiberg, in Saxony, a variety occurs composed of indistinct prismatic crystals and having a pearly lustre; this is the *Stangenspath* of Werner. Rounded masses, composed of diverging columnar particles, occur at Mount Paterno, near Bologna, and have hence been called the *Bolognese stone*. At Staffordshire and Derbyshire, is found an opaque massive variety of an earthy appearance and dirty-white color. This variety has been called *cawk*. The term *hepatite* has been applied to specimens which, by friction, emit a fetid odor.

In Cheshire, Conn., large distinct crystals, three or four inches long, and nearly transparent, are occasionally met with, in connection with vitreous copper and green malachite, in red sandstone. Smaller crystals of perfect transparency are frequently obtained, and large foliated massive specimens are abundant. Other similar localities are at Berlin, Farmington, and Southington, of the same state. A variety, indistinctly and very delicately fibrous, occurs in large masses at Pillar Point, opposite Sackett's Harbor, N. Y. It here constitutes a solid vein, from two to three feet thick, in secondary limestone. Large slabs are sometimes obtained and polished; and owing to the banded arrangement of the different shades of color, they are often extremely beautiful; the more common colors are a reddish-white, and a grayish or yellowish-white. The earthy and foliated varieties are found at the Perkiomen lead mine, in Pennsylvania. At Scoharie, it occurs with strontianite. Throughout the lead country of the west, heavy spar is very abundant, in connection with this ore. Crystals of heavy spar, and also a friable granular variety, occur abundantly at Eldridge's gold mine, in Buckingham Co., Virginia; three miles S. W. from Lexington, in Rockbridge Co.; a beautiful white variety is found on the plantation of J. Hord, Esq., Fauquier Co., Virginia.

The pure white varieties of heavy spar are sometimes ground up and employed as a white paint, either *per se*, or mixed with white lead. Otherwise, it is of no importance in the arts.

SULPHATO-CARBONATE OF BARYTA. *Thomson.*

194. The specimen, from which Dr. Thomson has derived the following description, consisted of a congeries of large six sided prisms, terminated by low six sided pyramids. H.=3. G.=4·141. *Lustre* vitreous. *Color* snow-white. Translucent. It contained Sulphate of Baryta 34·30, Carbonate of Baryta 64·82, Carbonate of Lime 0·28, Moisture 0·60=100. Locality unknown.

FLUCERINE. Spanialus hexagonus.

Fluate of Cerium.

195. *Primary form:* a hexagonal prism; occurs in six sided prisms and plates; sometimes with the angles of the prism replaced; also in amorphous masses. *Cleavage* most distinct parallel to P or the base of the prism.

H.=4—5. G.=4·7. *Lustre* weak. *Streak* white or slightly yellowish. *Color* dark-tile-red or almost yellow; deeper when the mineral is wet. Subtranslucent—opaque.

Its constitution, according to Berzelius, (Afhandlingar, v. 56,) is as follows;—

Peroxyd and Protoxyd of Cerium	82·64
Yttria	1·12
Fluoric Acid	16·24=100.

It is infusible, *per se*, before the blowpipe. In borax and salt of phosphorus, it fuses slowly but completely. The globule is blood-red in the exterior flame, but becomes colorless on cooling. In the interior flame it is colorless at all temperatures. In carbonate of soda it does not fuse, but swells out and is decomposed.

Obs. This mineral is of very rare occurrence, having been observed only at Finbo and Broddbo, near Fahlun, in Sweden, where it occurs imbedded in quartz and albite, accompanying pyrophysalite and orthite.

SUBSESQUIFLUATE OF CERIUM. Spanialus dodecahedrus.

196. Usually massive; sometimes exhibits traces of the rhombic dodecahedron.

H.=5. *Lustre* vitreous. *Streak* fine yellow. *Color* a beautiful yellow, with some red; and when impure, brownish-yellow. Subtranslucent—opaque.

According to Berzelius, (Afhand. v. 64,) it contains

Peroxyd of Cerium	84·20
Fluoric Acid	10·85
Water	4·95=100.

Infusible in the blowpipe flame, but blackens. On cooling, passes through dark-brown and red tints, and nearly reassumes its original color, being a little redder than at first. With borax, salt of phosphorus, and carbonate of soda, it acts like the last species. It dissolves in hot sulphuric acid, forming a yellow solution. With muriatic acid, chlorine is copiously evolved.

Obs. It accompanies the compact black allanite in small quantities at Bastnæs, in Sweden.

CARBONATE OF CERIUM. Spanialus quadratus.

Berzelius, Brewster's Journ. III. 334.

197. In thin four sided crystalline plates of a grayish-white color.

It contains, according to Hisinger, Oxyd of Cerium 75·7, Carbonic Acid 10·8, and Water 13·5. Exposed to a low red heat, it loses 19 per cent. of its weight, without changing its appearance.

Obs. It is found coating the Cerite of Bastnæs, in Sweden, and probably is produced by the decomposition of that mineral.

SILICATE OF CERIUM. Spanialus Wollastonii.

Wollastonite. Brewster's Jour. VI. 357.

198. *Primary form:* a regular hexagonal prism. *Cleavage* parallel to the axis of the prism.

Color pale-yellowish brown. Translucent.

Obs. Accompanies emerald in magnesian carbonate of lime, at Santa Fe de Bogota, in Peru. Some fragments, associated with emerald, are preserved in the British Museum.

MICROLITE. Spanialus octahedrus.

Shepard. Silliman's Amer. Journal, XXVII. 361.

199. *Primary form:* the regular octahedron. *Secondary forms:* figs. 3, 9, 17, Pl. I. *Cleavage* imperfect parallel with the faces of the octahedron.

H.=5—5·5. G.=4·75—5. *Lustre* resinous. *Streak* white, except when the color of the mineral is brown, it then resembles the color. *Color* straw-yellow—dark-reddish-brown. Transparent—subtranslucent.

Alone, before the blowpipe, it is unaltered. With borax, it fuses slowly into a yellow globule, which grows paler on cooling, and remains transparent, unless subjected to flaming, when it becomes nebulous, and presents on cooling a pale-yellow enamel. It is not readily acted upon by carbonate of soda. No action with nitric acid. It is supposed to contain, as its principal ingredient, the oxyd of cerium.

Obs. Occurs at Chesterfield, Mass., in the vein of albite, which contains the green and red turmaline, disseminated through the albite, and especially near its junction with the smoky quartz. The largest crystals yet seen, weigh but 0·4 of a grain. It was discovered by Prof. C. U. Shepard, and named as above, in allusion to the smallness of its crystals, from *μικρος*, *small*.

YTTRO-CERITE. Spanialus rhombicus.

200. Massive. *Cleavage* apparent parallel to a rhombic prism of 108° 30′.

H.=4·5—5. G.=3·447. *Lustre* glistening; vitreous—pearly. *Color* violet-blue, inclining to gray and white, often white; sometimes reddish-brown. Opaque. *Fracture* uneven.

According to Berzelius, (Afhandlingar, iv. 151,) it is composed of Fluoric Acid 25.05, Lime 47·63, Oxyd of Cerium 18·22, Yttria 9·11. It whitens before the blowpipe, previous to its attaining a red heat, but is infusible *per se*. With the addition of gypsum, it fuses into a bead, which on cooling becomes of a white color. In a pulverized state, it dissolves completely in heated muriatic acid, forming a yellow solution.

Obs. It occurs sparingly at Finbo and Broddbo, near Fahlun, in Sweden, imbedded in quartz, and associated with albite and topaz.

XENOTIME. Spanialus peritomus.

Phosphate of Yttria. Phosphorsaure Ytterde *of the Germans*.

201. *Primary form:* a right square prism. *Secondary form:* similar to fig. 54, Pl. I. M : e=about 135°. *Cleavage* perfect parallel to M.

H.=4·25—5. G.=4·5577. *Lustre* resinous. *Streak* pale-brown. *Color* yellowish-brown. Opaque. *Fracture* uneven and splintery.

According to the analysis of Berzelius, (Kong. Vet. Acad. Handl. 1824, p. 334,) it is composed of

Yttria	62·58
Phosphoric Acid	33·49
Subphosphate of Iron	3·93=100.

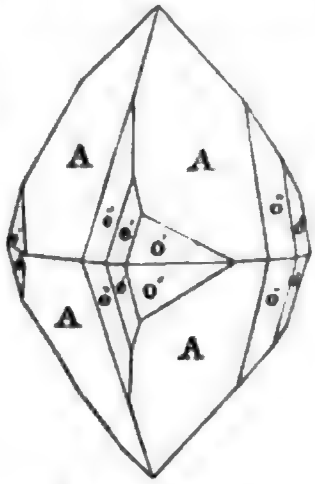
and consequently it contains 1 atom of Phosphoric Acid to 1½ of Yttria. Before the blowpipe, it comports itself like apatite, but differs from that mineral by its infusibility *per se*. With borax, it affords a colorless globule, which becomes milky on cooling. With biphosphate of soda, it dissolves with great difficulty into a clear colorless glass: in this particular, also, it differs from apatite, as that mineral fuses easily with this reagent. With carbonate of soda, it produces a strong effervescence, and a light-gray infusible slag. In acids, it is insoluble.

Obs. This mineral was discovered at Lindesnaes, in Norway, in a vein composed chiefly of a coarse granite.

TUNGSTATE OF LIME. SCHEELIUS PYRAMIDALIS.

Pyramidal Scheelium Baryte, *M.* Tungsten. Scheelite. *L.*

202. *Primary form:* a right square prism, or a square octahedron. *Secondary forms:* similar to figs. 55 and 57, Pl. I.; also the annexed figure; A : A (over a terminal edge)=100° 8′, A : A (over a basal edge)=130° 20′. A : e=140° 4′. *Cleavage* parallel to A perfect, though interrupted by a conchoidal fracture; traces parallel to e. *Compound crystals:* composition parallel to planes truncating the basal angle, or parallel to the lateral faces of a right square prism. *Imperfect crystallizations:* reniform shapes with columnar structure; also granularly massive.



H.=4—4·5. G.=6·076, of a white crystalline variety from Schlaggenwald, as determined by Haidinger. *Lustre* vitreous, inclining to adamantine. *Streak* white. *Color* white, inclining to yellow and brown; sometimes almost orange-yellow. Subtransparent—translucent. *Fracture* uneven. Brittle.

Consists of lime 19·40, and Tungstic Acid 80·417, according to Berzelius. Bucholz and Brandes obtained

	Bucholz.	Brandes, (Schweig. xx. 285.)
Tungstic Acid	78·00	76·50
Lime	19·06	16·50
Oxyd of Iron	——	1·47
Silica	——	2·94
Alumina	—— =97·06.	1·09=98·50.

It is infusible alone before the blowpipe, except that the thinnest edges are partially vitrified. With borax, it yields a white glass, whose transparency depends on the quantity of salt employed. When thrown into nitric acid, it becomes yellow, but does not dissolve.

Obs. Tungstate of lime is usually associated with primary rocks, and is commonly found in connection with tin ore, topaz, fluor, apatite, molybdena, or wolfram, in quartz.

It occurs at Schlackenwald and Zinnwald, in Bohemia; in fine crystals at Caldbeckfell, near Keswick, with apatite, molybdena, and wolfram. Schellgaden, in Salzberg; Harzegerode, in Anhalt; and Cornwall, are other localities of this mineral.

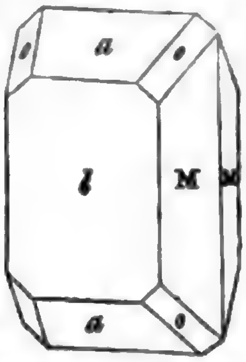
In the United States it is found both crystallized, in the forms above referred to, and massive, at Monroe and Huntington, Conn., at Lane's mine, where it is associated with wolfram, pyrites, rutile, native bismuth, in quartz.

Tungstate of lime has not been employed in the arts. If found in abundance, it would yield a yellow paint, (tungstic acid,) superior in beauty to chrome yellow. Small quantities have been sold by the proprietor of the above mine. This oxyd, or rather acid, occurs native at Monroe, Conn., in a pulverulent or earthy form, filling small cavities in this species, and also wolfram: it was first detected by Prof. Silliman, (Silliman's Amer. Jour. IV. 52.)

WHITE ANTIMONY. Stimmius rhombicus.

Prismatic Antimony-Baryte, *M.* Oxyd of Antimony. Antimony Bloom. Weiss-Spiess Glaserz, *W. Hof.* Spiesglanzweiss, *Haus.* Antimonbluthe, *L.* Antimoine Oxidé, *H.*

203. *Primary form:* a right rhombic prism; M : M=136° 58′. *Secondary form:* rectangular plates, with the lateral edges replaced by planes which are inclined at an angle of 136° 31′; acicular rhombic prism; also the annexed figure; M : ĕ=111° 58′, *a* : ĕ=144° 44′, *a* : *a* (adjacent planes) =70° 32′. *Cleavage* highly perfect parallel with M, and easily obtained. *Compound crystals:* composition of the second kind, parallel with ĕ; the union of thin plates by this kind of composition produces the common forms of this species, which were formerly supposed to be simple forms, and the faces of junction to be the cleavage joints. *Imperfect crystallizations:* structure lamellar, columnar, and granular.



H.=2·5—3. G.=5·566, crystals from Braünsdorf. *Lustre* adamantine, ĕ often pearly; shining. *Streak* white. *Color* snow-white, occasionally peach-blossom-red, and ash-gray. Translucent—subtransparent. Sectile.

Composition, according to Vauquelin, Oxyd of Antimony 86, ditto and Iron 3, Silica 8=97. It may therefore be considered, as Thomson remarks, a disilicate of antimony; but another analysis is needed, to determine with certainty its atomic constitution. It fuses in the flame of a candle, and before the blowpipe is entirely volatilized, covering the charcoal with a white coating.

Obs. The tabular crystallizations of this species occur at Przibram, in Bohemia, in small quantities, in veins traversing primitive rocks; and the prismatic have been observed at Braunsdorf, near Freiberg, in Saxony; Malaczka, in Hungary; Allemont, in Dauphiny; and elsewhere in Europe. It is usually associated with other ores of antimony, and also those of lead, together with blende and calcareous spar.

ANTIMONOPHYLLITE.

Breithaupt, Jahresbericht for 1832, p. 202.

204. Crystallized in thin unequiangular six sided prisms, of a grayish-white color. It contains Oxyd of Antimony. Locality unknown.

BISMUTH OCHRE. Bismutalus ochraceus.

Oxyd of Bismuth. Wismuthochre, *W.* Bismuth Oxydé, *H.*

205. Crystalline form not observed. Occurs massive and disseminated, pulverulent, earthy; also passing into foliated.

G.=4·3611, Büsson. *Lustre* adamantine—dull, earthy. *Color* greenish-yellow, straw-yellow, grayish-white. *Fracture* conchoidal—earthy.

It contains, according to Lampadius, Oxyd of Bismuth 86·4, Oxyd of Iron 5·1, Carbonic Acid 4·1, Water 3·4=99. Before the blowpipe, on charcoal, it is easily reduced to the metallic state, and subsequently the greater part may be dissipated.

Obs. It occurs pulverulent at Schneeberg, in Saxony; at Joachimstahl, in Bohemia; and with native gold and an ore of bismuth at Beresof, in Siberia.

BISMUTH BLENDE. Bismutalus dodecahedrus.

Arsenical Bismuth, *Breit.* Kieselwismuth. Silicate of Bismuth, *Thom.*

206. *Primary form:* according to Breithaupt, the rhombic dodecahedron, fig. 7, Pl. I. *Secondary forms:* figs. 30, 34, and 35, Pl. I. *Cleavage* parallel to the faces of the dodecahedron. It usually occurs in minute crystals, but also presents globular forms, composed of columnar, lamellar, or granular particles.

H.=3·5—4·5. G.=5·912—6·006. *Lustre* resinous, or adamantine. *Streak* yellowish-gray. *Color* dark hair-brown, yellowish-gray, and straw-yellow. Subtransparent—opaque. *Fracture* uneven. Rather brittle.

It consists, according to Hünefield, of

Carbonate of Bismuth	58·8
Arsenic Acid	2·2
Silica	23·8
Arsenate of Cobalt, Copper, and Iron	5·9
Matrix	9·1=99·8.

A careful analysis by Kersten, (Pogg. Ann. xxvii. 81,) obtained the following for its composition:

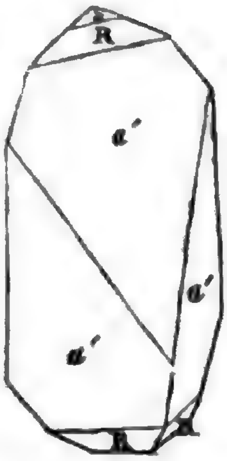
Oxyd of Bismuth	69·38
Silica	22·23
Phosphoric Acid	3·31
Peroxyd of Iron	2·40
Sesquoxyd of Manganese	0·30
Fluoric Acid and Water	1·01=98·6.

Heated in a glass tube, it decrepitates, and affords a trace of water. It fuses before the blowpipe into a dark-yellow mass, and gives out a sublimate destitute of smell. It fuses and froths on charcoal, staining it yellowish-brown, sometimes with a tinge of green. Fuses readily with carbonate of soda, into a button, at first greenish-yellow, and then reddish-yellow. On charcoal, with borax, it is ultimately reduced to the metallic state. With biphosphate of soda, it fuses into a yellow globule, which becomes colorless on cooling.

Obs. This mineral is found in the neighborhood of Schneeberg, in Saxony, in quartz. It was first described by Breithaupt, (Pogg. Ann. 1827, p. 175.)

CALAMINE. Zincalus rhombohedrus.

Rhombohedral Zinc-Baryte, *M.* Zinkspath, *L.* Carbonate of Zinc.



207. *Primary form:* an obtuse rhombohedron; R : R=107° 40'. *Secondary forms:* figure of a crystal from Retzbanya, a' : a'=113° 31', and figure of a crystal from Siberia. Primary planes generally curved and rough. *Cleavage* perfect parallel to R. *Imperfect crystallizations:* reniform, botryoidal or stalactitic shapes; also massive, of a granular composition, sometimes impalpable. Occasionally, decomposition produces earthy and friable varieties. It also occurs in crystalline incrustations and as pseudomorphs imitative of crystals of calcareous spar.

H.=5. G=4·334, Smithson,—4·442 Haidinger, who examined a honey-yellow crystallized variety. *Lustre* vitreous, inclining to pearly. *Streak* white. *Color* white, often grayish, greenish, brownish, sometimes green and brown. Subtransparent—translucent. *Fracture* uneven, imperfectly conchoidal. Brittle.

It is composed, according to Smithson, (Nicholson's Jour., vi. 76,) of

	From Somersetshire.	From Derbyshire.
Oxyd of Zinc	35·2	34·8
Carbonic Acid	64·8=100.	65·2=100,

and is, therefore, a simple carbonate of zinc.

It loses its transparency in the blowpipe flame, but does not melt. The carbonic acid is driven off, and oxyd of zinc is obtained or passes off in white flakes. It dissolves with effervescence in nitric acid. It becomes negatively electrified by friction. Calamine is found both in veins and beds, especially in company with galena and blende; also with copper and iron. It usually occurs in calcareous rocks, and is generally associated with electric calamine.

Fine specimens of calamine are obtained in Siberia, one variety has a dark brown color and contains cadmium; another is of a beautiful bright green. Other localities are Dognatzka, and the Bannat of Temeswar, in Hungary; Bleiberg and Raibel, in Carinthia; Altenberg, near Aix la Chapelle. Concentric botryoidal groupes are met with in the Mendip hills, and at Wanlockhead, in Dumfreisshire.

In the United States, calamine is found in great abundance in Jefferson county, Missouri, at a lead mine called Valle's diggings. The Franklin iron mine, of New Jersey, and the Perkiomen lead mine, Pennsylvania, afford it in small quantities. At the Perkiomen mine it only occurs in a pulverulent form, and results from the decomposition of red zinc ore.

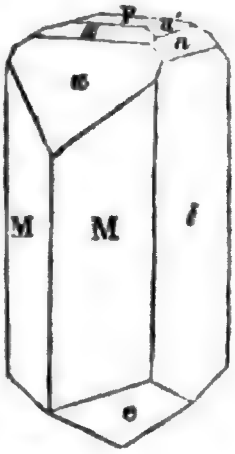
Smithson has analyzed a *dicarbonate* of zinc, of which the following is a description.

Occurs encrusting other minerals,having much the appearance of chalk. H.=2—2·5. G.=3·58—3·6. *Lustre* dull. *Color* white, grayish or yellowish; opaque. Immersed in water, it absorbs about one third of its weight of that liquid.

It contains Carbonic Acid 13·52, Oxyd of Zinc 69·36, Water 15·10=97·98. Dissipated in the reducing flame with an evolution of an abundance of flowers of zinc, which are deposited on the charcoal.

ELECTRIC CALAMINE. ZINCALUS PERITOMUS.

Prismatic Zinc-Baryte, *M.* Siliceous Oxyd of Zinc. Galmei, (in part,). Zink glas, *Haus.* Zinc Oxidé Silicifère, *H.*



208. *Primary form:* a right rhombic prism; M : M=103° 53′ and 76° 7′. *Secondary form:* figure of a crystal from Altenberg, near Aix la Chapelle, M : M = 76° 7′, M : ē = 141° 46′, P : a′ = 154° 14′, P : a=124° 37′, P : *a′*=148° 20′, P : *a*=118° 23′. This crystal is differently modified at its two extremities, and like crystals of turmaline, and other hemihedrally modified crystals, its opposite extremities exhibit opposite electricities, either by friction or the application of heat. *Cleavage* perfect parallel to M, traces parallel to P. *Imperfect crystallizations:* stalactitic, mammillated, botryoidal, and fibrous forms; also massive, composition granular.

H.=4·5—5, the latter when crystallized. G=3·434 Smithson; —3·379 Haidinger. *Lustre* vitreous, subpearly on P, sometimes adamantine. *Streak* white. *Color* white; sometimes blue, green, yellow, or brown. Transparent—translucent. *Fracture* uneven. Brittle.

Its constituents are, according to Smithson, (Nicholson's Jour, vi. 78,) and Berzelius, (Kong. Vet. Acad. Handl. 1819, p. 141,) are

			Altenberg.
Silica	25·0	24·893	66·37
Oxyd of Zinc	68·3	66·837	26·23
Water	4·4	7·460	7·40
Carbonic Acid	—	0·450	—
Oxyds of Lead and Tin	—=97.7. S.	0·276=99.916. B.	—=100. B.

When pulverized, it dissolves in heated sulphuric or muriatic acid, and on cooling, the solution gelatinizes. In the blowpipe flame, it decrepitates, loses its transparency, intumesces, and emits a green phosphorescent light. It is infusible alone; but with borax melts into a clear glass, which becomes opaque on cooling. The hemihedral crystals assume polarity when rubbed or heated.

Obs. Electric calamine and calamine, are usually found associated with one another in veins, in calcareous rocks, accompanied by ores of blende, iron, and lead. The localities of this species are the same as given for the preceding. Pseudomorphs, imitative of calcareous spar, are common in Derbyshire, and also at Schemnitz, in Hungary.

WILLEMITE. ZINCALUS ACROTOMUS.

209. *Primary form:* an obtuse rhombohedron; R : R= about 133°. *Secondary form:* similar to fig. 110. *Cleavage* indistinct at right angles with the vertical axis. Occurs also in reniform masses; also granular—impalpable.

H.=5—5·5. G.=4—4·1. *Lustre* resinous. *Streak* white or yellowish. *Color* yellow, yellowish-brown, reddish-brown. Translucent—opaque.

It is a silicate of zinc, containing a little oxyd of iron.

The following is an analysis, by Dr. Thomson, of a specimen supposed to belong to this species.

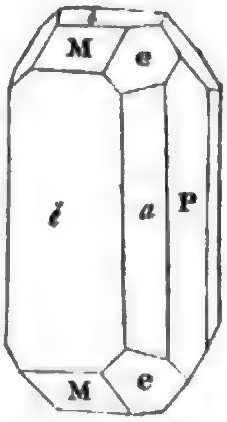
Oxyd of Zinc	68·77
Silica	26·97
Peroxyd of Iron	1·48
Alumina	0·66
Do. with a trace of Zinc and Iron	0·78
Water	1·25=99·91.

It decrepitates before the blowpipe, tinging the flame green, but does not fuse. With nitric or muriatic acid, it forms a jelly.

Obs. It is occasionally met with, associated with calamine, upon the Old Mountain, in Limburg.

HOPEITE. ZINCALUS DIATOMUS.

Brewster. Trans. Royal Soc. Edin. X, 107.



210. *Primary form:* a right rhombic prism; M : M=101° 24′ and 78° 36′. *Secondary form:* M : ē=140° 42′, M : ĕ=129° 18′, ĕ : *a*=130° 47′, P : *a*=139° 13′. *Cleavage* parallel with ĕ highly perfect. Plane P striated. It occurs also in reniform masses, and amorphous.

H.=2·5—3. G.=2·76. *Lustre* vitreous; somewhat pearly upon ĕ. *Streak* white. *Color* grayish-white; reddish-brown when compact. Transparent—translucent. Possesses double refraction. Sectile.

It dissolves without effervescence in the muriatic and nitric acids, but is slowly affected by sulphuric acid. It gives out its water of crystallization in the blowpipe flame, and then melts into a clear colorless globule, which tinges the flame green. The globule obtained with borax, remains clear on cooling. With soda, it affords a scoria which is yellow when hot, and gives out copious fumes of zinc and some of cadmium. The fused mineral forms a fine blue glass, with a solution of cobalt. Hopeite appears, therefore, to be a compound of phosphoric acid and zinc, with a small portion of cadmium, and some water.

Obs. It has been observed only in the calamine mines of Altenberg, near Aix la Chapelle. It was first distinguished as a species by Sir David Brewster, and named in honor of Prof. Hope, of Edinburgh.

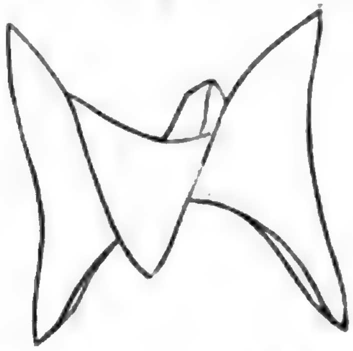
SPATHIC IRON. MARANTALUS RHOMBOHEDRUS.

Brachytypous Parachrose-Baryte, *M.* Carbonate of Iron. Sparry Iron. Brown Spar. Stahlstein. Sphærosiderite. Clay Iron Stone.

211. *Primary form:* an obtuse rhombohedron; R : R=107°. *Secondary forms:* similar to figs. 112, 113, Pl. II.; also 113, with the planes e of 119; e : e=136° 34′.

The faces often occur curved, as in the annexed figures. Fig. 1 is a singular instance of several curvatures arising in part from the compound nature of the crystal. *Cleavage* perfect parallel to R. *Imperfect crystallizations:* botryoidal and globular forms; occasionally in silky fibrous masses; also of a coarse or impalpably granular structure.

1.



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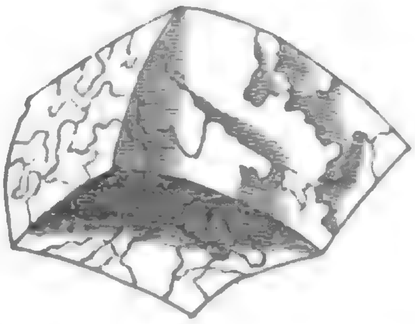


H.=3—4. G.=3·7317—3·829. *Lustre* vitreous—pearly. *Streak* white. *Color* ash-gray, yellowish-gray, greenish-gray, also brown, and brownish-red; sometimes white. Translucent—subtranslucent. *Fracture* uneven. Brittle.

It constituents are, according to Klaproth, (Beitrage, iv. 110,) Thomson, (Min. i. 445,) and Bischoff, (Ann. des Mines, 2d ser. i. 279.)

	From Dankerode.	Slitt lead mine, Durham.	Var. Sphærosiderite
Protox. Iron	57·50	54·570	52·128
Carbonic Acid	36·00	35·900	32·231
Protox. Mang.	3·50	1·155	——
Lime	1·25	3·176	} 9·965
Magnesia	——	——	
Alumina	——	——	5·676
Moisture	—— =98·25, K.	2·630=97·431, T.	—— =100, B.

In the blowpipe flame it blackens, giving off carbonic acid, and ultimately an oxyd of iron is obtained, which is attractable by the magnet. Alone, it is infusible. It colors borax green. It dissolves with difficulty in nitric acid, and scarcely effervesces, unless previously pulverized. Exposure to the atmosphere darkens its color, rendering it often of a blackish-brown, or brownish-red color.

Obs. Sparry iron occurs in several of the rock strata, in gneiss, mica-slate, graywacke, and in connection with coal formations. It is often associated with metallic ores. At Freiberg it occurs in silver veins. In Cornwall it accompanies tin. It is also found accompanying copper and iron pyrites, galena, vitreous copper, &c. Occasionally it is to be met with in trap rocks.

In the region in and about Styria and Carinthia, this ore forms coherent tracts in gneiss, which extend along the chain of the Alps, on one side into Austria, and on the other into Saltzburg. At Harzgerode, in the Hartz, it occurs in fine crystals in gray-wacke; also in Cornwall, Alston Moor, and Devonshire.

The *Sphærosiderite* variety has a spheroidal form and radiated structure; it occurs at Hanau, where it occupies cavities in greenstone. Clay iron stone, which is a mixture of carbonate of iron and clay, occurs in the coal beds in the neighborhood of Glasgow; also at Mouillar, Magescote, &c., in France.

At Roxbury, Conn., a vein of considerable size occurs in a vein of quartz, which traverses a stratum of gneiss for the distance of a mile. It is also obtained in considerable quantities at Plymouth, Vt. In small quantities it occurs at Monroe, Conn., in Lane's mine.

This ore is employed very extensively for the manufacture of iron and steel. On the Styrian bed, at the celebrated Erzberg, between Eisenerz and Vordenberg, 1200 men are constantly employed. The beds which occur in the coal formation in England, supply all the ore requisite for the immense quantity of iron annually smelted in Great Britain.

JUNKERITE. Marantalus rhombicus.

Dufrénoy. Ann. de Chim. et de Phys. LVI. 198.

212. *Primary form:* a right rhombic prism; M : M=108° 26′. *Secondary form:* a rectangular octahedron similar to fig. 89, Pl. II., with curved faces. *Cleavage* parallel with the lateral planes; highly perfect.

H.=3·5. G.=3·815. *Lustre* of external surface rather dull; of cleavage face, brilliant. *Color* yellowish-gray.

It contains, according to Dufrénoy,

Protoxyd of Iron	53·6	47·9
Carbonic Acid	33·5	30·0
Silica	8·1	16·8
Magnesia	3·7=98·9	3·9=98·6.

Before the blowpipe, with borax, it fuses into a yellowish-green glass, which becomes brown when the proportion of Junkerite is small.

Obs. This species appears to be identical in composition with spathic iron, and if so, carbonate of iron, like carbonate of lime, must rank among the dimorphous substances.

It has been found covering the surface of small quartz veins, which traverse the gray-wacke at the mine of Poullaouen, in a gallery of research. It was first observed by M. Paillette, sub-director of the mine, who named it in honor of the director, M. Junker.

DIALLOGITE. Marantalus decrepitans.

Macrotypous Parachrose-Baryte, *M.* Carbonate of Manganese. Rhodochrosite, and, (when mixed with Silicate of Manganese,) Allagite, Photizite, Rhodonite.

213. *Primary form:* an obtuse rhombohedron; R : R=105° 51′. *Secondary form:* similar to fig. 119, Pl. II. *Cleavage* parallel to R. *Imperfect crystallizations:* globular and botryoidal forms, having a columnar structure; sometimes indistinct. Also granular varieties, occasionally of an impalpable structure.

H.=3·5. G.=3·592. var. from Kapnik. *Lustre* vitreous, inclining to pearly. *Streak* white. *Color* various shades of rose-red; brownish. Translucent—subtranslucent. *Fracture* uneven. Brittle.

It is composed of

		From Nagyag.
Oxyd of Manganese	54·60	56·00
Carbonic Acid	33·75	38·60
Oxyd of Iron	1·87	——
Silica	4·37	——
Lime	2·50=97·09, Du Menil.	5·40=100, Berthier.

The action of the blowpipe changes the color to gray, brown, and black, and produces a strong decrepitation. It is infusible *per se.* With glass of borax it fuses readily into a violet-blue bead. It effervesces strongly with nitric acid. On exposure to the air, its color is changed to a brown. Some bright rose-red varieties become paler.

Obs. Diallogite occurs commonly in veins along with ores of silver, lead, and copper; it is said to have been found also in transition mountains with other ores of manganese.

It is not uncommon in the Saxon mines; it occurs also at Nagyag and Kapnik, in Transylvania, near Ellingerode in the Hartz, &c.

Breithaupt has separated from this species the ore from Kapnik, which contains, according to Berthier, (mechanical mixture in part?) 21 per cent. of Silica, 30·4 of Carbonic Acid, 41 of Protoxyd of Manganese, and 4·3 of Lime. Its Hardness he states to be 4·5—5. G.=3·592.

TRIPLITE. MARANTALUS QUADRATUS.

214. Imperfectly crystalline. Cleavage in three directions perpendicular to each other; one the most distinct.

H.=5—5·5. G.=3·439—3·775. *Lustre* resinous, inclining to adamantine. *Streak* yellowish-gray. *Color* blackish-brown. Subtranslucent—opaque. *Fracture* small conchoidal.

According to Vauquelin's analysis, it consists of Oxyd of Iron 31, Oxyd of Manganese 42, and Phosphoric Acid 27.

Before the blowpipe it fuses easily into a black scoria. It dissolves readily in nitric acid, without effervescence.

Obs. It occurs at Limoges, in France, in a vein of quartz in granite, accompanied by apatite.

In the United States it is met with in considerable abundance, at Washington, Conn., where its situation is similar to that at Limoges. It is associated with pulverulent diallogite. It is found in small quantities accompanying spodumene, at Sterling, Mass.

HETEPOZITE. MARANTALUS FRENCHI.

Ann. of Phil. 1831. Ann. de Chim. XXX. 294.

215. *Primary form:* an oblique rhombic prism; occurs massive. *Cleavage* parallel with the faces of an oblique rhombic prism.

H. about 6. G. when fresh 3·52, after exposure 3·39. *Lustre* resinous, like that of apatite. *Color* greenish-gray or bluish; becomes violet after long exposure, and its lustre is changed to submetallic.

It contains, according to Dufrénoy, (Ann. de Ch. et de Ph. xli. 442,)

Phosphoric Acid	41·77
Oxyd of Iron	34·89
Red Oxyd of Manganese	17·57
Silica	0·22
Loss by Heat	4·40=98·85.

It dissolves in acids, excepting its silica. Before the blowpipe it yields by fusion a brown enamel, of a submetallic lustre.

Obs. It is met with at Thoreaux, in the Haute Vienne. It was first observed and described by Dufrénoy.

HURAULITE. Marantalus fusilis.

Vauquelin, Ann. de Chim. et de Ph. XXX. 302, and *Dufrénoy*, XLI. 338.

316. *Primary form:* an oblique rhombic prism; M : M=117° 30′, and 62° 30′. *Secondary form:* the primary, with the lateral solid angles deeply replaced. *Cleavage* none.

H. above 3. G.=2·27. *Lustre* vitreous. *Color* reddish-yellow, a little lighter than the color of hyacinth. Transparent.

It contains, according to Dufrénoy, Phosphoric Acid 38, Oxyd of Iron 11·1, Oxyd of Manganese 32·85, Water 18=99·95. It is very fusible. Before the blowpipe it melts into a black button, having a metallic lustre; heated in a glass tube, it affords some water.

Obs. It occurs in minute crystals, occupying small veins in granite, near Limoges, in the Commune of Hureaux, whence its name. It is associated with a fibrous phosphate of iron.

It resembles zircon in color, but is readily distinguished by the irregular form of its crystals and its inferior hardness.

CUBE ORE. Arealus cubicus.

Hexahedral Lirocone Malachite, *M.* Hexahedral Olivenite, *J.* Pharmakosiderit, *Haus.* Wurfelerz, *W.* Fer Arseniaté, *H.*

217. *Primary form:* the cube. *Secondary forms:* figs. 28, 33, also 28 and 5 combined, Pl. I. *Cleavage* parallel with the primary faces imperfect. P sometimes striated parallel to its edge of intersection, (fig. 28,) with a. Faces on the angles often curved.

It occurs rarely massive; composition granular.

H.=2·5. G.=3. *Lustre* adamantine, not very distinct. *Streak* olive-green—brown, commonly pale. *Color* olive-green, passing into yellowish-brown, bordering sometimes upon hyacinth-red, and blackish-brown; also into grass-green, and emerald-green. Subtranslucent. Rather sectile.

According to Berzelius, (Kong. Vet. Acad. Handl. 1824, p. 354,) it is composed of

Arsenic Acid	37·28
Peroxyd of Iron	39·20
Water	18·61
Phosphoric Acid	2·53
Oxyd of Copper	0·65
Insoluble Matter	1·76=99·93.

Exposed to a gentle heat, it becomes of a red color; a higher temperature causes intumescence, but drives off little or no arsenic, and leaves a red powder. Copious arsenical fumes are emitted, when supported on charcoal before the blowpipe, and a metallic scoria is obtained in the reducing flame, which acts on the magnetic needle.

Obs. Cube ore is obtained at the mines of Huel Gorlan, Huel Unity, and Carharrak, in Cornwall, coating cavities in quartz, and associated with several of the ores of copper: also at St. Leonhard, in France; at Schneeburg and Schwarzenburg, in Saxony.

The iron sinter of Freiberg is closely allied to this species. It occurs of a yellowish-gray color, in reniform masses, soft, approaching to friable, coarse, earthy fracture, and adhering strongly to the tongue. Its constituents, according to Kersten's analysis, (Schweigger's Jahrbuch, xxiii. 176,) are,

Arsenic Acid	30·25
Peroxyd of Iron	40·45
Water, with trace of Sulphuric Acid,	28·50=99·20

ARSENATE OF IRON.

218. Massive. Usually in small porous masses, irregularly crystallized. Berzelius states that he has observed right square prisms, terminated by four sided pyramids. *Color* pale. *Streak* white.

It contains, according to Berzelius and Boussingault,

Arsenic Acid	50·78	49·6
Peroxyd of Iron	34·85	34·3
Oxyd of Lead	——	0·4
Arsenate of Alumina	0·67	——
Water	15·55=101·85, Berz.	16·9=101·2, Bouss.

If heated in a glass tube, it gives out water, without an evolution of arsenous acid. Before the blowpipe, it becomes yellow, without altering its form.

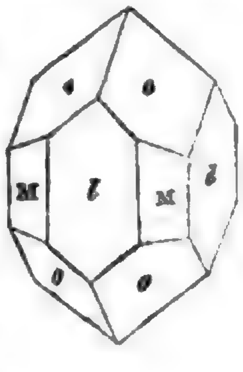
Obs. It occurs at Antonia Pareira, Villa Rica, in Brazil, in small quantities in a silicious perhydrate of iron; also at Loaysa, near Marmato, in Popayan.

SCORODITE. Arealus trimetricus.

Dystomic Fluor-Haloide, *Haid.* Skorodite. Martial Arseniate of Copper, *P.* Cuprous Arseniate of Iron, *Bournon.* Skorodit, *Breit.*

219. *Primary form:* a right rhombic prism; M : M=119° 2′. *Secondary form:* M : ē=149° 31′. *o* : *o*=115° 6′ and 102° 1′. *Cleavage* indistinct parallel with M and ē.

H.=3·5—4. G.=3·163—3·3, Haidinger. *Lustre* vitreous—sub-adamantine. *Streak* white. *Color* pale-leek-green, or liver-brown. Subtransparent—translucent. *Fracture* uneven.



It contains, according to Chenevix, (Phil. Trans., 1801, pp. 191, 218,) and Ficinus, (Schweigger's Jahrbuch, iv. 198,)

Arsenous Acid	33·5		31·40
Oxyd of Copper	22·5	Protox. Mang.	4·00
Oxyd of Iron	27·5		36·25
Water	12·0		18·00
Silica	3·0	Sulphuric Acid	1·54
Lime	——		2·00
Magnesia	——		2·00
Gangue	——=98·5, C.		1·40=96·59, F.

It gives out an alliaceous odor before the blowpipe, and fuses into a reddish-brown scoria, which acts upon the magnet, when all the arsenic is expelled.

Obs. A brown-colored variety occurs in the primitive mountains of Schwarzenberg, in Saxony, associated with arsenical pyrites, and at Löling, near Huttenberg, in Carinthia, with leucopyrite. A leek-green scorodite is found in the Cornish mines, coating cavities of ferruginous quartz. Minas Geraes, in Brazil, have afforded some fine specimens.

The name of this species is derived from σκοροδον, *garlic*, and was applied because of its odor under the blowpipe.

CHENOCOPROLITE. Arealus Argentiferus.

Gansekothig-Erz *of the Germans.*

220. Mammilated.

H.=2—3. *Lustre* resinous. *Streak* white. *Color* yellow, or pale-green. Translucent. *Fracture* conchoidal.

Before the blowpipe, it evolves copious arsenical fumes, and fuses into a blackish scoria; when the heat is continued on charcoal, it fuses and yields a button of silver, but the slag contains metallic iron, which strongly affects the magnet. Chencoprolite appears, therefore, to be an arsenate of silver and iron.

Obs. The principal localities of this species are in the Hartz, at the mines of Clausthal. It is also found in Cornwall, and at Allemont in Dauphiny. When abundant, it is highly valued as an ore of silver.

Chenocoprolite is a translation of the German name, which was given it in allusion to its peculiar color and general appearance.

TRIPHYLINE. Arealus rhombicus.

221. *Primary form:* a right rhombic prism; M : M=about 132°. *Cleavage* parallel with P perfect; parallel with M and one of the diagonals, imperfect, the latter the least so. Occurs commonly massive.

H.=5. G.=3·6. *Streak* grayish-white. *Color* greenish-gray; also bluish. Translucent in thin fragments.

It contains, according to Fuchs, (Erdmann und Schweigger-Seidel Journ. für Chem. iii. 98,) Phosphoric Acid 41·47, Protoxyd of Iron 48·57, Protoxyd of Manganese 4·7, Lithium 3·4, Silica 0·53, Water 0·68=99·35. It fuses easily before the blowpipe, and loses 0·68 per cent. of water at a red heat. It dissolves readily in borax, and affords a green glass. It is soluble in the acids.

Obs. It occurs in large quantities at Bodenmais. It was first described by Fuchs, and named from τρις *three*, and φυλη, *family*, in allusion to its containing three phosphates.

A similar compound from Keiti, in Finland, has been analyzed by Nordenskiold, and named *Tetraphyline*. It differs in physical characters from the preceding, in presenting a yellow color on its surface of fresh fracture, which by degrees becomes black. The following analysis exhibits its peculiarities in composition: Phosphoric Acid 42·6, Protoxyd of Iron 38·6, Protoxyd of Manganese 12·1, Magnesia 1·7, Lithia 8·2=103·2; the excess is supposed to be owing to an incorrect determination of the quantity of lithia.

CACOXENITE. Arealus radiatus.

Kakoxene, *Steinmann.*

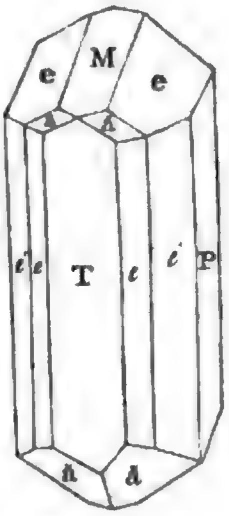
222. Occurs in minute fibres, diverging from a point.

H.=3—4. G.=3·38. *Lustre* silky. *Streak* yellowish. *Color* yellowish-brown.

Obs. It is found at Hrbeck, near Zbirow, in Bohemia, disposed on brown iron ore. It might readily be mistaken for Carpholite, which is found in similar situations, from which it differs in its deeper color. The word Cacoxenite is derived from κακος, *bad*, ξενος, *guest*, in allusion to the injurious effects of the phosphoric acid it contains on the iron extracted from the ore.

VIVIANITE. Arealus rhomboideus.

Prismatic-Iron, Mica, *M*. Dichromatic Euclas-Mica, *Haid*. Phosphate of Iron. Blue Iron Earth. Blaue Eisenerde, *Wern*. Fer Phosphaté, *H*.



223. *Primary form* :a right rhomboidal prism; M : T = 125° 18′. *Secondary form* :, P : *e′* = 125° 56′, T : *e*=165° 25′, M : e=150° 30′, M : *e*= 117° 40′, T : ă=125° 25′, Phillips. Surface P smooth, others striated. *Cleavage* highly perfect parallel with P, traces in other directions. *Imperfect crystallizations :* reniform and globular; also in light particles, forming superficial coatings.

H.=1·5—2. G=2·661. *Lustre* pearly, metallic-pearly on P. The other faces exhibit a vitreous lustre. *Streak* bluish-white, soon changing to indigo blue. The color of the powder, obtained by pulverizing the dry mineral, is liver-brown. *Color* various shades of blue and green; deepens by exposure. It is usually green at right angles with the vertical axes, and blue parallel to it. The two colors mingled, produce the dirty-blue color which the mineral ordinarily presents. Transparent—translucent; opaque on exposure. *Fracture* not observable. Thin laminæ perfectly flexible. Sectile.

It contains, according to Vögel and Stromeyer, (Untersuchungen, p. 274,)

	Bodenmais.	Cornwall.
Protoxyd of Iron	41·0	42·38
Phosphoric Acid	26·4	28·69
Water	31·0=98·4, V.	28·93=100, S.

It decrepitates in the blowpipe flame, and immediately loses its color and becomes opaque; if pulverized, it fuses into a dark brown or black scoria, which affects the magnetic needle. Heated in a glass tube, it yields a considerable quantity of pure water. It dissolves in dilute nitric and sulphuric acids.

Obs. It occurs associated with magnetic and common iron pyrites in copper and tin veins; also in narrow veins with gold, traversing gray-wacke; occasionally, it is met with in trap rocks. The friable varieties occur in clay, and are sometimes associated with bog iron ore.

Near St. Agnes, in Cornwall, transparent crystals of an indigo color, have been found an inch in diameter and two in length, disposed on magnetic pyrites. Bodenmais, and the gold mines of Vöröspatak, in Transylvania, afford crystalline specimens. On the promontory of Kertz, in the Black Sea, it has been found in large indistinct crystals, occupying the interior of shells. The earthy variety, which is sometimes known under the name of *blue iron* or *native Prussian blue*, occurs in Greenland, Stiria, Carinthia, Cornwall, &c. The friable varieties have been discovered in bog iron ore in several peat swamps, in the Shetland Isles; at Ballagh, in the Isle of Man, accompanied with animal matter, particularly the horns of elk and deer. It has also been met with in a soft friable clay near an old slaughter house, which was removed for the foundation of the west bridge at the foot of the Castle rock, Edinburgh, indicating no very remote origin.

Fine translucent crystals of Vivianite, presenting a dark blue color, are met with at Imleytown, New Jersey.

At Allentown, Monmouth Co., N. J., it occurs in considerable abundance, both crystallized in nodules and earthy, imbedded in bog iron ore, and associated with clays. It often fills the interior of belemnites and gryphites, in the ferruginous sand formation.

The *blue iron earth*, or earthy variety of this species, contains

	Klaproth, (Beit. iv. 190.)	Brandes, (Schweig. Jahrb. i. 97.)
Phosphoric Acid	32·0	30·320
Protoxyd of Iron	47·5	43·775
Water	20·0	25·000
Alumina	——	0·700
Silica	——=99·5.	0·025=99·820.

Its color is at first grayish-white, but becomes blue on exposure to the air: it soils slightly, and has a somewhat harsh feel.

ANGLARITE. Arealus divergens.

Ann. des Mines, XII. 303. Mullicite, *Thomson*, Min. I. 453. Diphosphate of Iron.

224. In fibrous masses and radiating needles; also in cylindrical masses, consisting of a congeries of small needle-form crystals, radiating from the centre of the cylinder.

G.=1·787, Thomson; the variety from Gloucester Co., N. J. *Lustre* vitreous. *Streak* lighter than the color. *Color*, gray, bluish, bluish-black, brown. Translucent—opaque.

It contains, according to Thomson, Vauquelin, and Berthier,

	Mullica Hill.	Haute Vienne.	Anglar.
Phosphoric Acid	24·00	24·8	28·82
Protoxyd of Iron	42·65	51·0	56·67
Water	25·00	15·0	14.51
Protoxyd of Manganese	——	9·0	——
Grains of sand	7·90=99·55, T.	——=99·8, V.	——=100, B.

It fuses before the blowpipe into a black globule. In the matrass, it yields water.

Obs. This species occurs at Anglar, in the Haute Vienne; also at Mullica Hill, Gloucester Co., N. J., in bluish-black cylindrical masses, composed of divergent fibres or acicular crystals.

CARPHOSIDERITE.

Karphosiderite, *Breithaupt*. Brewster's Journal. VIII. 181.

225. In reniform masses.

H.=4—4·5. G.=2·5. *Lustre* resinous. *Streak* unchanged, glimmering. *Color* pale and deep straw-yellow. *Feel* greasy.

It contains Oxyd of Iron, Phosphoric Acid, and Water, with small quantities of Manganese and Zinc. It dissolves readily in borax, and fuses with biphosphate of soda into a black scoria.

Obs. This species was first distinguished by Breithaupt, among some Greenland specimens. It resembles oxalate of iron. Its name alludes to its straw-yellow color.

PYROSMALITE. Arealus rhombohedrus.

Pyrodmalit, *L.* **Fer muriaté,** *H.* **Hexagonal Pyrosmalite-Mica,** *Breit.*

226. *Primary form:* a rhombohedron. *Secondary form:* a hexagonal prism, fig. 114, Pl. II., also the same solid with the alternate terminal edges replaced. *Cleavage* perfect, perpendicular to the vertical axis. It also occurs massive.

H.=4—4·5. G.=3·81, Hisinger. *Lustre* of a, the terminal face of the hexagonal prism, pearly; of other planes, less so. *Streak* paler than the color. *Color* pale liver-brown, passing into gray and pistachio-green; usually brown externally, and light-greenish-yellow internally. *Fracture* uneven, rather splintery. Somewhat brittle.

According to Hisinger and Berzelius, (Afhand. iv. 317,) it consists of

Silica	35·850
Peroxyd of Iron	35·480
Sesquoxyd of Iron	23·444
Chlorine	3·760
Water	3.600
Lime	1·210=103·344.

It becomes reddish-brown in the blowpipe flame, and emits copious fumes of muriatic acid. In a strong heat it fuses into a black slag, which at last becomes a round globule, attractable by the magnet. With borax it fuses readily, and presents the appearances characteristic of iron and manganese. It dissolves in muriatic acid, leaving a small residuum of silica.

Obs. Pyrosmalite has been found only at Bjelkegruvan, one of the iron mines of Nordmark, in Wermeland, Sweden, where it is associated with calc spar, pyroxene, apophyllite, and magnetic iron. A crystal from this locality, in the museum at Stockholm, is nearly an inch in diameter and one and a quarter inches long, and weighs five and a half ounces; its form is a six-sided prism. The other secondary form given above, is presented by a crystal in the cabinet of Mr. Heyer, of Dresden.

CRONSTEDTITE. Arealus foliaceus.

Rhombohedral Melane-Mica, *M.* **Cronstedtite,** *Steinmann.* **Hydrous Silicate of Iron,** *Thom.*

227. *Primary form:* a rhombohedron. Occurs in hexagonal prisms, tapering towards their summit, or adhering laterally; also in diverging groups, reniform, and amorphous. *Cleavage* highly perfect, parallel to a, or the base of the prism.

H.=2·5. G.=3·348. *Lustre* brilliantly vitreous. *Streak* dark leek-green. *Color* brownish-black. Opaque. Not brittle. Thin laminæ elastic.

Steinmann, (Schweigger's Jahrbuch, ii. 69,) obtained for its composition,

	Var. Cronstedtite.	
Silica	**22·452**	**22·83**
Protoxyd of Iron	**58·853**	**57·61**
Water	**10·700**	**10·70**
Protoxyd of Mang.	**2·885**	**3·82**
Magnesia	**5·078=99·968, S.**	**3·25=98·21, S.**

Before the blowpipe it froths a little, but does not melt. With borax it affords a hard black opaque bead. When in the state of powder, it gelatinizes in concentrated muriatic acid.

Obs. It accompanies hydrate of iron and calc spar, in veins containing silver ores, at Przibram, in Bohemia. It occurs also at Wheal Maudlin, in Cornwall, in diverging groups; also with quartz and magnetic pyrites, at the mines of Conghonas do Campo, in Brazil.

CHLOROPAL.

Bernhardi and *Brandes*, Schweigger's Jahrbuch, V. 29.

228. Massive; structure impalpably granular; earthy.

H.=3—4. G.=1·727—1·870; earthy varieties, the second a conchoidal specimen; 2·105, Thomson, a Ceylon chloropal. *Color* greenish-yellow and pistachio-green. Opaque—subtransparent. Fragile. *Fracture* conchoidal and splintery.

It contains, according to Bernhardi, Brandes, and Thomson, (Min. i. 464.)

	Hungary.	Hungary.	Ceylon.
Silica	46	45·00	53·00
Protoxyd of Iron	33	32·00	Peroxyd 26·04
Magnesia	2	2·00	1·40
Alumina	1	0·75	1·80
Water	18=100. B. & B.	20·00=99·75, B. & B.	18·00=100·24, T.

Infusible before the blowpipe, but blackened and rendered opaque. With carbonate of soda it forms a clear glass, exhibiting some red points. With borax it fuses into a clear glass, having no red points.

Obs. The mineral analyzed by Thomson, differs essentially from the specimens from Unghwarin, Hungary. The latter are described as breaking readily into a kind of parallelopiped, the upper end and two adjoining lateral edges of which, have the opposite magnetic pole from the lower end and the other two edges. The Ceylon variety appeared to Thomson to be destitute of this peculiarity.

Closely allied to this species is the *green iron earth*, Grune Eisenerde, of Werner. It occurs in reniform, botryoidal, and globular masses, presenting an impalpably granular structure. *Lustre* resinous. *Streak* yellowish-gray. *Color* siskin-green, passing into black and yellow. Brittle. It becomes brown and black before the blowpipe, but does not melt: it is not dissolved in nitric acid. It has been observed at Schneeberg, in Saxony, and in the Hollerterzing, in the county of Sayn.

SIDEROSCHISOLITE.

Wernekingk. **Poggendorf's Annalen, I. 387. Chamoisite, *Berthier*, Ann. des Mines, V. 393. Hydrous Disilicate of Iron, *Thomson*.**

229. In very minute crystals; also massive.

H.=2—3. G.=3—3·4. *Lustre* splendent; sometimes earthy, when massive. *Streak* leek-green, greenish-gray. *Color* pure velvet-black when crystallized; dark-greenish-gray. Opaque.

According to Wernekingk and Berthier, the crystallized and massive varieties contain,

	Sideroschisolite.	Chamoisite.
Silica	16·3	12·0
Protoxyd of Iron	75·5	50·5
Alumina	4·1	6·6
Water	7·3	14·7
Carbonate of Lime	——	14·4
Carbonate of Magnesia	—— =103·2, W.	1·2 =99·4, B.

These varieties are therefore each a *hydrous disilicate of iron*, and differ only in the proportion of water. Heated, it at first becomes black and magnetic; afterwards it changes to an ochre-red. In a glass tube, water is evolved. It forms a jelly with muriatic acid. The massive variety, Chamoisite, effervesces with acids, on account of the carbonate of lime with which it is mixed. The solution obtained with the crystalline variety, sideroschisolite, is greenish-yellow.

Obs. Crystallized specimens occur in cavities of magnetic pyrites and sparry iron ore in small crystals, at Conghonas do Campo, in Brazil. Chamoisite occurs in beds of small extent, in a limestone mountain, abounding in ammonites, at Chamoisin, in the Valais.

NONTRONITE.

Ann. de Ch. XXXVI. *Berthier.*

230. Structure like clay. *Color* pale-straw or canary-yellow, greenish. Opaque. *Feel* unctuous; tender. Affords an odor, when breathed on. Flattens and grows lumpy under the pestle. Polished by friction.

It contains Silica 44, Peroxyd of Iron 29, Alumina 3·6, Magnesia 2·1, Water 18·7, Clay 1·2. Immersed in water, it disengages air, becomes subtranslucent, and increases in weight. Slightly heated, it loses its water, and assumes the color of red oxyd of iron. It is readily acted on by muriatic acid, and, in part, is gelatinized. Calcined, it becomes sensibly magnetic.

Obs. Occurs in reniform masses, seldom larger than the fist, among the manganese, in the arrondissement of Nontron, in France.

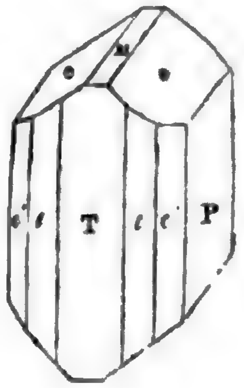
Closely allied to this species, is the *Pinguite* of Leonhard, of which the following is a description:

Massive. *Lustre* slightly resinous. *Streak* lighter than the color. *Color* siskin and oil-green. Does not adhere to the tongue, and emits a feeble argillaceous odor when struck. Extremely soft, resembling new made soap.

It contains, according to Kersten, Silica 36·9, Oxyd of Iron 35·6, Alumina 1·8, Magnesia 0·45, Oxyd of Manganese 0·14, Water 25·10.

COBALT BLOOM. COBALTALUS RUBELLUS.

Prismatic Cobalt-Mica, *M.* Diatomous Euclas-Haloide, *Haid.* Prismatic Red Cobalt, *J.* Red Cobalt Ochre. Arseniate of Cobalt. Cobalt Mica. Diarseniate of Cobalt, *Thom.* Cobalt bluthe, *Haus.* Cobalt Arseniaté, *H.*



231. *Primary form:* a right rhomboidal prism; M : T=124° 51′. *Secondary form:* a crystal from Schneeberg; M : e=149° 12′, e : e=118° 23, T : *e*=155° 5′, T : *e*′=127° 6′, *e* : *e*=130° 10′, *e*′ : *e*′=94° 12′. Surface P and T vertically striated. *Cleavage* parallel to P highly perfect, scarcely visible parallel to M and T. Perfect crystals of this mineral are always very minute. The imperfectly crystalline varieties present globular and reniform shapes, having a drusy surface, and a columnar structure; the columnar particles are sometimes stellularly divergent, and thus compose a granu-

lar variety. It also occurs as a powder coating other minerals, and then constitutes what is sometimes called *cobalt crust*.

H.=1·5—2; the lowest degree upon P. G.=2·948. *Lustre* of P pearly, especially of the cleavage face; of other faces, adamantine, inclining to vitreous. When it is an incrustation on other substances, its lustre is commonly dull and earthy. *Streak* a little paler than the color. *Color* crimson, and peach-blossom-red, sometimes pearl-gray, or greenish-gray. The red tints incline to blue, if seen in a direction perpendicular to P. The powder of the dry pulverized mineral has a deep lavender-blue tinge, which is not the case when crushed in water. Transparent—subtranslucent. *Fracture* not observable. Thin laminæ flexible in one direction. Sectile.

According to Bucholz, (Gehlen's Journ. 2d ser. ix. 314,) cobalt bloom contains Arsenic Acid 37·9, Oxyd of Cobalt 39·2, Water 22·9. Darkens *per se* in the blowpipe flame, and emits copious arsenical fumes; in the reducing flame, it fuses into a globule of arsenid of cobalt. With borax, and other fluxes, it yields a fine blue glass.

Obs. It occurs at Schneeberg, in Saxony, in micaceous scales, stellularly aggregated. Brilliant specimens, consisting of minute aggregated crystals, are met with at Saalfield, in Thuringia; and at Riegelsdorf, in Hessia. The earthy peach-blossom varieties have been observed in Dauphiny; in Cornwall; at the lead mine of Tyne Bottom, near Alston, in Cumberland. A perfectly green variety occurs at Platten, in Bohemia, and sometimes red and green tinges have been observed on the same crystal.

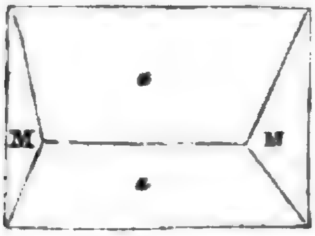
Cobalt bloom, when abundant, is valuable for the manufacture of smalt. This species resembles red antimony, and capillary red copper ore. From both of these minerals, however, the effects under the blowpipe readily distinguish it. Moreover, the color of the former is more sombre, of the latter, more brilliant than cobalt bloom.

WHITE LEAD. Cronalus rhombicus.

Diprismatic Lead-Baryte, *M.* White Lead Ore. Blei Erde, *Wern.*

232. *Primary form:* a right rhombic prism; M : M=117° 13′, and 62° 47′. *Secondary forms:* both from Johangeorgenstadt.

1



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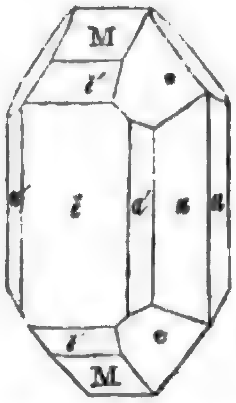


M : ĕ=120° 24′. M : ĕ′=150°, *a* : *a*=140° 15′, and 39° 45′, ĕ : *a*′=

145° 20′, ĕ : *a*=109° 53′. *Cleavage* parallel to M often perfect. *Compound crystals:* several of these forms are figured in Pl. IV., and have already been fully described in § 76. *Imperfect crystallizations:* rarely fibrous; frequently granularly massive and impalpable.

H.=3—3·5. G.=6·465—6·480. *Lustre* adamantine, inclining to vitreous or resinous; sometimes pearly. The former is sometimes metallic, if the colors are dark. *Streak* white. *Color* white, gray, grayish-black, sometimes tinged blue or green by some of the salts of copper. Transparent—subtranslucent. *Fracture* conchoidal. Very brittle.

Its composition is as follows:

	Leadhills.
Carbonic Acid	16·00
Protoxyd of Lead	82·00
Water	2·00=100, Klaproth.

Before the blowpipe, it decrepitates, becomes yellow, then red, and finally, with care, a globule of lead may be obtained. It dissolves readily, and with effervescence in dilute nitric acid.

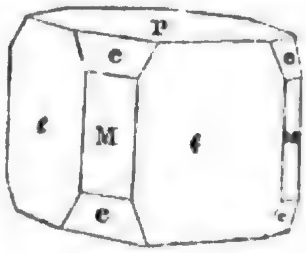
Obs. Leadhills and Wanlockhead are among the finest localities of this mineral. At these places it occurs with other ores of lead in transition slate. Beautiful crystals are met with at Johangeorgenstadt; at Nertchinsk and Beresof, in Siberia; near Bonn, on the Rhine; at Clausthal, in the Hartz; at Bleiberg, in Carinthia; and at Mies and Przibram, in Bohemia. In England, it has been observed at Alston Moor, Keswick, and particularly in Cornwall, where, in the mine of St. Minvers, it occurs in exceedingly delicate crystals. Opaque pseudonomorphs, imitative of crystals of Anglesite have been met with at Leadhills.

Fine crystals have been obtained at the Perkiomen lead mines, near Philadelphia. It also occurs at Valle's Diggings, Jefferson Co., Missouri, and in small quantities, principally as an incrustation, at Southampton, Mass. The lead mines of St. Lawrence Co., N. Y., contain much of this ore, where it has been formed by a decomposition of the galena; it has not been observed there in a crystalline state.

CORNEOUS LEAD. Cronalus quadratus.

Brachytypous Lead-Baryte, *M.* Murio-Carbonate of Lead. Chloro-Carbonate of Lead, *Thomson.*

233. *Primary form*: a right square prism. *Secondary forms:* similar to figs. 53 and 61, Pl. I.; and also combinations of the two. M : *e*=135°; also the annexed figure. *Cleavage* parallel to M.



H.=2·75—3. G.=6—6·1. *Lustre* adamantine. *Streak* white. *Color* white, gray, and yellow. Transparent—translucent. Rather sectile.

According to Klaproth's analysis, (Beitrage iii. 141,) it contains

Lead	39·17
Chlorine	13·56
Protoxyd of Lead	43·32
Carbonic Acid	8·51=104·56

Before the blowpipe it melts readily into a yellow globule, which on cooling becomes white and crystalline. On charcoal, lead is obtained.

Obs. The localities of this rare mineral are Matlock, in Derbyshire; Hausbaden, near Badenweiller, in Germany; also Southampton, Mass., in the United States. At each of these localities, it accompanies other ores of lead.

COTUNNITE. Cronalus Vesuvianus.

Cotunnia, *Monticelli.* Cotunnite, *Von Kobell.* Chlorid of Lead, *Thomson.*

234. In acicular crystals.

May be scratched by the nail. *Lustre* adamantine; inclining to silky or pearly. *Streak* white. *Color* white.

According to Berzelius, it contains Chlorine 25·48, and Lead 74·52, and is, therefore, a simple Chlorid of Lead.

It fuses readily in the flame of the blowpipe and colors the flame blue, giving off white vapors, which condense on the charcoal. With carbonate of soda it yields a globule of lead. It dissolves in about 27 times its weight of cold water.

Obs. This mineral was observed by Monticelli and Covelli, in the crater of Mount Vesuvius, after the eruption of 1822. It was accompanied with chlorid of sodium, and chlorid and sulphate of copper. It was named in honor of a distinguished medical man at Naples.

CERASITE. Cronalus peritomus.

Peritomous Lead-Baryte, *M.* Muriate of Lead. Dichlorid of Lead. Berzelite, *Levy.* Kerasite.

235. *Primary form:* a right rhombic prism; M : M=102° 27′. It occurs in masses, having a columnar structure, often radiated, and admitting of a highly perfect cleavage parallel to M.

H.=2·5—3. G.=7—7·1. *Lustre* pearly upon cleavage faces. *Streak* white. *Color* white, with a tinge of yellow or red. Feebly translucent—opaque.

It is composed, according to Berzelius, of

Lead	83·2
Chlorine	13·77
Carbonic Acid	1·03
Silica	1·46
Water	0·54=100,

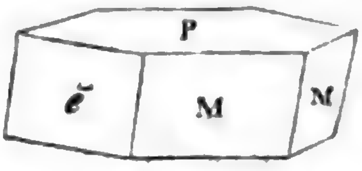
and, therefore, consists of 2 atoms of lead and 1 atom of chlorine.

It decrepitates slightly under the heat of the blowpipe, and readily fuses, producing a globule of a deeper yellow color than the original specimen. On charcoal, lead may be obtained. Treated with peroxyd of copper and salt of phosphorus, the flame assumes an intensely blue color.

Obs. This rare mineral occurs at the Mendip Hills, in Somersetshire, on earthy black manganese. Its name is derived from κερας, *horn.*

LEADHILLITE. Cronalus acrotomus.

Axotomous Lead Baryte, *M.* Sulphato-Tricarbonate of Lead. Rhomboidal Carbonate of Lead.



236. *Primary form:* an acute oblique rhombic prism; P : M=89° 36′, or its supplement 90° 24′, and M : M=59° 40′, or its supplement 120° 20′. *Secondary forms:* the annexed figure is placed with a side lateral edge towards the observer. The plane ĕ truncates the front lateral edge. The lettering of the planes will show their respective situations. A few of their interfacial angles are as follows; M : M=120° 20′, P : M (the front plane M) =90° 24′, P : M

(M to the right) =89° 36′, M : ĕ=119° 50′. *Cleavage* perfect parallel to P, in traces in the direction of M and ĕ.

H.=2·5. G.=6·2—6·5. *Lustre* pearly on the basal plane; in other parts resinous, somewhat adamantine. *Streak* white. *Color* white, passing into yellow, green or gray. Transparent—translucent. Conchoidal *fracture* scarcely observable. Rather sectile.

Its constituents, as determined by Berzelius, are

Carbonate of Lead	71·1
Sulphate of Lead	30·0=101·1.

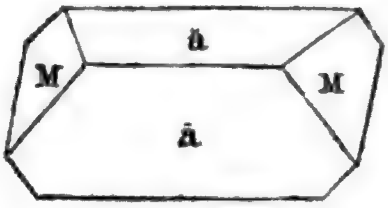
It therefore contains three atoms of the former to one of the latter.

Before the blowpipe, it intumesces at first, and then turns yellow; but returns to a white color on cooling. It effervesces briskly in nitric acid, and leaves a white precipitate.

OBS. This ore has been principally found at Leadhills, associated with other ores of lead, in a vein traversing gray-wacke; Grenada is also stated to be a locality of it. The crystals seldom exceed an inch in length, and are commonly smaller. The compound forms are very complex.

DYOXYLITE. CRONALUS FLEXILIS.

Prismatoidal Lead-Baryte, *M.* Suphato-Carbonate of Lead.



237. *Primary form:* an oblique rhombic prism; M : M = *Secondary form:* Plane M is usually rounded, and the crystals aggregated lengthwise and seldom distinct. *Cleavage* parallel to the shorter diagonal; Laminæ flexible like gypsum.

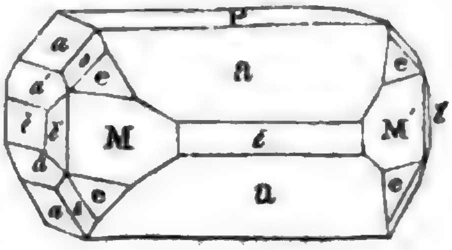
H.=2—2·5. G.=6·8—7. *Lustre* pearly upon the perfect face of cleavage; on other parts adamantine, inclining to resinous. *Streak* white. *Color* greenish-white, pale-yellow or gray. Transparent—translucent.

Its constituents, according to Brooke, are Carbonate of Lead 46·9, and Sulphate of Lead 53·1. It fuses before the blowpipe into a globule, which is white on cooling. It dissolves in nitric acid, but without a perceptible effervescence.

OBS. It occurs at Leadhills, with other ores of lead. A massive variety has of late been observed in Siberia.

ANGLESITE. CRONALUS ANGLESEANUS.

Prismatic Lead-Baryte, *M.* Sulphate of Lead. Lead Vitriol.



238. *Primary form:* a right rhombic prism; M : M=103° 49′. *Secondary form:* M : ē=141° 54′, M : ĕ= 128° 6′, P : a=140° 36′, P : e=115° 40′, P : ē or ĕ=90°. *Cleavage* parallel to M and P, but interrupted. The planes M and ē are often vertically striated, and a, horizontally. *Imperfect crys-*

tallizations: Lamellar and granular varieties of various sizes of individuals, are of frequent occurrence.

H.=2·75—3. G.=6·259—6·298. *Lustre* highly adamantine in some specimens, in others, inclining to resinous and vitreous. *Streak* white. *Color* white, tinged yellow-gray, green and sometimes blue. Transparent—opaque. *Fracture* conchoidal. Very brittle.

It contains, according to Klaproth, (Beitrage, iii. 162,) Stromeyer, (Hoffman's Handbuch, iv. 43,) and Thomson, (Min. i. 559,)

			Leadhills.
Sulphuric Acid	25·75	26·0191	25·655
Protoxyd of Lead	70·50	72·9146	74·045
Protoxyd of Iron	——	0·1151	——
Protoxyd of Manganese	——	0·1654	——
Water	2·25=98·5, K.	0·1242=99·3384, S.	0·300=100, T.

It is, therefore, a simple sulphate of lead.

In the flame of a candle it decrepitates, and frequently assumes a slightly reddish tinge on the surface. In powder, it melts in the blowpipe flame into a white slag, which yields metallic lead by the addition of carbonate of soda.

Obs. This ore of lead results, in many instances, from the decomposition of galena. At Leadhills it frequently occurs, occupying the cubical cavities of galena, or is disposed on the surface of this ore. This locality, and also Wanlockhead, afford large and beautiful crystals of this mineral, some of which are transparent, of a tabular form, and are several inches in diameter. Pary's mine, in Anglesea; Mellanoweth, in Cornwall; Clausthal and Zellerfeld, in the Hartz; Badenweiler, in the Brisgau, are other localities. Small, but extremely perfect transparent crystals have been brought from Fondon, in Grenada. The massive varieties are met with in Siberia, Andalusia, and Alston Moor.

In the United States, no very beautiful crystallizations have been obtained. It, however, occurs in the Missouri lead mines, and also in the lead mine at Southampton, Mass., and at the Walton gold mine, Luzerne Co., Va.

HEDYPHANE. Cronalus amorphus.

239. Occurs in amorphous masses traversed by numerous fissures; also, according to Breithaupt, in short hexagonal prisms.

H.=3·5—4. G.=5·46—5·493. *Lustre* adamantine; sometimes subresinous. *Streak* and *Color* white, or grayish-white. Translucent.

Its composition, according to Kersten's analysis, (Ann. de Ch. et de Ph. xlviii. 178,) is as follows,

Protoxyd of Lead	52·950
Lime	14·034
Chlorine	2·029
Arsenic Acid	22·780
Phosphoric Acid	8·207=100.

It fuses before the blowpipe into an opaque globule, which does not crystallize on cooling. It tinges the flame greenish-blue, without producing any odor. With salt of phosphorus it froths and gives out the odor of muriatic acid. Globules of lead are obtained when fused on charcoal, and white arsenical fumes are given off. A scorta remains, which is not reducible in the interior flame, but crystallizes on cooling.

Obs. It occurs at Longbanshyttan, in Sweden, associated with brown garnet and manganese spar. Its name is derived ἡδυς, *sweet*, and φαινειν, *to appear*.

PLUMBO-RESINITE. CRONALUS RESINIFORMIS.

Sexaluminate of Lead, *Thomson*. Plombgomme. Bleigummi, *of the Germans*. Plumbo-gummite.

240. Aggregations of columnar particles presenting externally reniform or globular shapes; also impalpable.

H.=4—4·5. G.=6·3—6·4. *Lustre* resinous. *Streak* white. *Color* yellowish and reddish-brown; also yellowish-white. Translucent. Resembles in color and appearance gum-arabic. *Fracture* conchoidal.

Berzelius and Dufrénoy obtained the following as its constituents:

Protoxyd of Lead	40·14		37·51
Alumina	37·00		34·23
Water	18·80		16·14
Sulphurous Acid	0·20		——
Lime, Ox. of Iron, and Mang.	1·80	Phos. Lead	7·80 (from the gangue.)
Silica	0·60=98·54, B.		2·11=97·79, D.

A quick application of the heat of the blowpipe produces decrepitation, and it soon parts with the water it contains, but does not fuse. On charcoal it forms an enamel, like some of the zeolites, without fusing. With borax a colorless glass is obtained; a reduction of the ore is not effected. Concentrated hydrochloric acid decomposes the powdered plumbo-resinite.

OBS. It occurs in clay slate, at Huelgoet, near Poullaouen, in Brittany, associated with galena, blende, iron pyrites, and pyromorphite; also in a lead mine near Beaujeu. It resembles some varieties of mammillated blende.

PYROMORPHITE. CRONALUS HEXAGONUS.

Rhombohedral Lead-Baryte. Phosphate of Lead. Braunbleierz, Grunbleierz, *Wern.* and *Hoff.* Traubenblei, *Haus.* Arsenate of Lead. Mimetene.

241. *Primary form:* the regular hexagonal prism. *Secondary form:* fig. 125, Pl. II. M : *e*=150°, M : e=131° 45′, P : e=138° 15′. *Cleavage* in traces parallel to M. M commonly horizontally striated. *Imperfect crystallizations:* globular, reniform, and botryoidal forms, having an internal columnar structure; also fibrous and granularly massive grains strongly coherent.

The identity in the crystallization of the phosphate and arsenate of lead, requires their union in the same species. In the farther description of them, however, it is preferred to treat of them separately. They may be distinguished as variety 1, speciosus; and variety 2, alliaceus.

PYROMORPHITE. CRONALUS HEXAGONUS. VAR. SPECIOSUS.

H.=3·5—4. G.=6·5871—6·915, according to Thomson. *Lustre* resinous. *Streak* white, sometimes yellowish. *Color* green, yellow-brown, of different shades; sometimes fine orange-yellow, owing to an intermixture with chromate of lead. Subtransparent—subtranslucent. *Fracture* subconchoidal, uneven. Brittle.

Its compositon is, according to Kersten, (Ann. de Ch. et de Ph. xlviii. 157,)

Protox. Lead	72·17	75·830
Lime	6·47	3·711
Chlorine	2·00	2·110
Phosphoric Acid	19·36=100.	18·349=100.

Klaproth, (Beit. iii. 146,)

Protox. of Lead	78·58	78·40
Muriatic Acid	1·65	1·70
Peroxyd of Iron	——	0·10
Phosphoric Acid	19·73=99·96.	18·37=98·57.

The first analysis by Kersten, was of a specimen belonging to the variety polysphœrite, being in small spheres of a brown color, and was obtained in the mine Sonnenwirbel, near Freiberg. Sp. gr.=6·092. The second was a similar specimen from Mies, in Bohemia. Klaproth's first of the above analyses, was performed on a brown phosphate from Huel Goet: the second was a siskin-green phosphate from Zschopau. Before the blowpipe, on charcoal, it melts without addition, and the globule on cooling, assumes a polyhedral form, and a dark color. In the reducing flame, the globule becomes bluish. It dissolves readily in heated nitric acid.

Obs. Pyromorphite occurs principally in veins, and accompanies other ores of lead. Fine specimens occur at Leadhills and Wanlockhead; at Poullaouen and Huel Goet, in Brittany; at Zschopau, and other places, in Saxony; in the Hartz, Bohemia, and Hungary.

The green variety has been found in fine specimens at the Perkiomen lead mine, near Philadelphia, and at the lead mine in Lenox, Maine.

MIMETENE. CRONALUS HEXAGONUS. VAR. ALLIACEUS.

H.=2·75—3·5. G.=6·41, Gregor. *Lustre* resinous. *Streak* white. *Color* pale-yellow, passing into brown. Subtransparent—translucent. Sectile.

It is composed, according to Whöler, (Pogg. Ann. iv. 167,) who analyzed a specimen from Johangeorgenstadt, of

Protoxyd of Lead	67·64
Arsenic Acid	21·09
Lead	7·39
Chlorine	2·56
Phosphoric Acid	1·32=100.

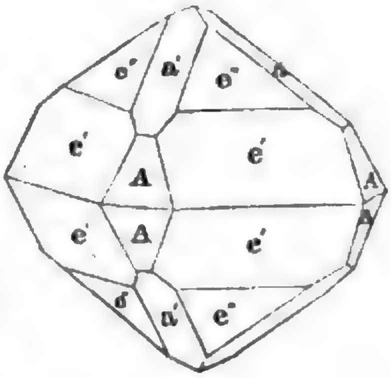
It dissolves easily in nitric acid, especially if heated. Before the blowpipe, in a gold spoon, it fuses into a brownish-yellow mass, which does not crystalline externally on cooling. On charcoal, it gives out copious arsenical fumes, and affords a globule of lead.

Obs. Fine specimens of this mineral occur at Huel Unity, near Redruth, in Cornwall, and in several other of the Cornish mines; also at Beeralston, in Devonshire. At St. Prix, in the department of the Saone, in France, it occurs in capillary crystals; at Johangeorgenstadt, in fine crystals of a yellow color; at Nertschinsk, Siberia, in reniform masses of a brownish-red color.

MOLYBDATE OF LEAD. Cronalus pyramidalis.

Pyramidal Lead-Baryte, *M.* Gelb-bleierz, *Wern.* Yellow Lead Ore. Bleigelb, *Haus.*

242. *Primary form:* a square octahedron ; A : A (over a terminal edge)=99° 40′ ; A : A (over a basal edge)=131° 35′. *Secondary forms:* similar to fig. 54, Pl. I.; also the annexed fig., e′ : e′ (over basal edge)=115° 7′, A : a′=150° 46′, e′ : e″=168° 49′. *Cleavage* very smooth parallel to A. It occurs also granularly massive ; grains of various sizes, and firmly coherent.



H.=2·75—3. G.=5·706, Hatchett ; 6·76, Haidinger. *Lustre* resinous. *Streak* white. *Color* wax-yellow, passing into orange-yellow ; also siskin- and olive-green, yellowish-gray, grayish-white. Subtransparent—subtranslucent. *Fracture* subconchoidal. Brittle.

Its constituents are, according to Klaproth, (Beit. ii. 275,) Hatchett, (Phil. Trans. 1796, p. 233,) and Göbel, (Schweigger's Jahrbuch, vii. 71.)

Molybdic Acid	34·25	37·00	40·5
Protoxyd of Lead	64·42	58·40	58·0
Oxyd of Iron	——	3·08	——
Silica	—— =98·67, K.	0·28 =98·76, H.	—— =98·5, G.

In the blowpipe flame it decrepitates briskly, and becomes of a darker color, which again disappears. On charcoal it fuses and is absorbed by it, leaving behind some globules of metallic lead. With borax in the exterior flame, it fuses readily into a colorless glass. In the interior flame, the glass is transparent, but on cooling, becomes all at once dark and opaque. Melts readily with salt of phosphorus, producing a green glass, when the proportion of the mineral is small, but black and opaque, if large.

Obs. This species occurs in veins of limestone with other ores of lead, at Schwarzenbach, Bleiberg, and Windish-Kappel, in Carinthia. It is also met with at Rezbanya, in Hungary, and at Moldawa, in the Bannat, where its crystals have considerable resemblance to chromate of lead. It is found in small quantities at the Southampton lead mines, Mass., and at the Perkiomen mine, near Philadelphia.

VANADATE OF LEAD. Cronalus Vanadicus.

243. Occurs in irregular crystallizations, globular masses, or incrustations. The larger globules exhibit traces of six-sided prisms. H.=2·75. G.=6·6623—7·23. *Lustre* fracture of surface resinous. *Streak* white. *Color* light brownish-yellow, straw-yellow, reddish-brown. Subtranslucent—opaque. *Fracture* even, or flat conchoidal. Brittle.

According to Berzelius, the Mexican variety consists of Chlorid of Lead 25·33, Vanadate of Lead 74·00, Hydrous Oxyd of Lead 0·67. Dr. R. D. Thomson obtained

Chlorine	2·446
Lead	7·063
Protoxyd of Lead	66·326
Vanadic Acid	23·436
Peroxyd of Iron and Silica	0·163=99·434.

This is equivalent to 1 part of Chlorid of Lead, to 9 of Sesquivanadate of Lead.

Before the blowpipe, in a pair of forceps, it fuses, and retains its yellow color on cooling: if kept some time in fusion, however, it changes into a steel-gray porous mass, which, upon charcoal, yields globules of metallic lead. On charcoal it fuses with much frothing into a bead, resembling the original assay. It forms green solutions with the sulphuric and muriatic acids, and a beautiful yellow solution with nitric acid.

Obs. This mineral was first discovered at Zimapan, in Mexico, by Del Rio. It has since been obtained among some of the old workings at Wanlockhead, in Dumfriesshire, where it occurs in small globular masses, sprinkled over calamine, or in thin coatings on the surface of that mineral.

TUNGSTATE OF LEAD. Cronalus ponderosus.

Tungstate of Lead. Scheelsaures Blei.

244. *Primary form:* a square octahedron or prism. Occurs in modified square octahedrons or prisms; often indistinctly aggregated. *Cleavage* parallel to the base of the prism.

H.=2·75.—3. G.=7·904—8·088. *Lustre* resinous. *Streak* white. *Color* green, gray, brown, and red. Faintly translucent.

It is composed of Tungstic Acid 52, and Oxyd of Lead 48.

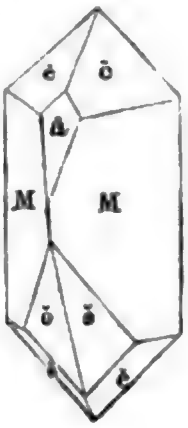
It melts before the blowpipe, and gives off vapors of lead, leaving a dark-colored, sub-metallic crystalline globule, whose streak is pale-gray.

Obs. Tungstate of lead occurs at Zinnwald, in Bohemia, associated with quartz and mica; also at Bleiberg, in Carinthia, accompanying the molybdate of lead.

CHROMATE OF LEAD. Cronalus hyacinthus.

Hemi-prismatic Lead-Baryte, *M.* Red Lead Ore.

1.



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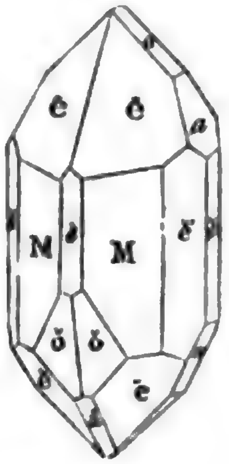


245. *Primary form:* an oblique rhombic prism; M : M=93° 40′, P : M=99° 11′. *Secondary forms:* P : ē=102° 30′, M : ē=136° 50′, M : ĕ=133° 10′, ē : ē=119°, ĕ : ĕ=107° 30′. *Cleavage* tolerably distinct parallel to M, less so parallel to P. Surface M streaked longitudinally. The faces mostly smooth and shining. *Imperfect crystallizations:* imperfectly columnar; granularly massive.

H.=2·5—3. G.=6—6·004. *Lustre* adamantine–vitreous. *Streak* orange-yellow. *Color* various shades of hyacinth-red. Translucent. sectile.

The constituents of the pure chromate of lead are Chromic Acid 31·71, Protoxyd of Lead 68·29.

It blackens in the blowpipe flame, and decrepitates if quickly heated. It may be fused into a shining slag containing globules of lead. It undergoes a partial reduction in glass of borax, coloring at it the same time green. It dissolves without effervescence in nitric acid, and produces a yellow solution.

Obs. Siberia is the principal locality of the chromate of lead. It occurs also at Beresof, in narrow veins, traversing decomposed gneiss, and associated with gold, pyrites, galena, quartz, and Vauquelinite. In Brazil, at Conconhas do Campo, fine crystallized specimens are met with, where it occurs in decomposed granite.

MELANOCHROITE. Cronalus rubeus.

Subsesquichromate of Lead, *Thom.*

246. *Primary form:* a rhombic prism. Crystals usually tabular, and reticularly interwoven. Occurs also massive.

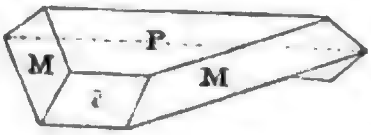
Very soft. G.=5·75. *Lustre* resinous, glimmering. *Streak* brick-red. *Color* between cochineal and hyacinth-red; becomes lemon-yellow on exposure. Subtranslucent—opaque.

It contains, according to Hermann, (Poggendorf's Annalen, xxviii. 162,) Chromic Acid 23·64, Protoxyd of Lead 76·36=100. On charcoal, before the blowpipe, it fuses readily into a dark mass, which is crystalline when cold. In the reducing flame, lead is sublimed. It gives a green bead with the fluxes.

Obs. It occurs in a limestone rock at Beresofsk, in the Ural, associated with chromate of lead, Vauquelinite, pyromorphite, and galena. It was first analyzed and described by Hermann.

VAUQUELINITE. Cronalus Vauquelini.

247. *Primary form:* an oblique rhombic prism. Occurs usually in minute irregularly aggregated crystals, of a dark green or black color. *Compound crystals:* similar to the annexed figure; composition of *the third kind,* parallel to a plane on the acute solid angles, P : P (of the two individuals,) =134° 30′, and P : ē=149° nearly. *Imperfect crystallizations:* reniform and botryoidal shapes, and granular structure; also amorphous.



H.=2·5—3. G.=5·5—5·78. External *lustre* adamantine, often faint. *Streak* siskin-green or brownish. *Color* dark-green, sometimes nearly black. Faintly translucent—opaque. *Fracture* uneven. Rather brittle.

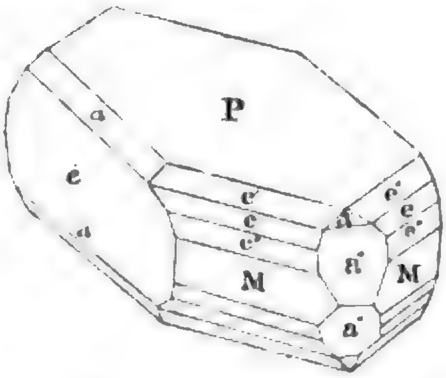
According to Berzelius, it contains Oxyd of Lead 60·87, Oxyd of Copper 10·80, Chromic Acid 28·33=100.

Before the blowpipe, on charcoal, it slightly intumesces and fuses into a gray submetallic globule, yielding at the same time, small beads of lead. It is partly soluble in nitric acid.

Obs. Vauquelinite occurs with chromate of lead at Beresof, in Siberia, generally in mammillated or amorphous masses, or thin crusts. It has also been observed at Port Gibaud, in the Puy de Dome; it is stated to occur along with the chromate of lead of Brazil. Levy gives its specific gravity at 6·8—7·2, and hardness above 4·0.

CALEDONITE. CRONALUS DIATOMUS.

Paratomous Lead-Baryte, *Haid.* Cupreous Sulphato-Carbonate of Lead.



248. *Primary form:* a right rhombic prism; M : M=95°. *Secondary form:* e′ : e′=108°, M : ĕ=132° 30′, P : *a*=126°, P : e′=126°, P : e=115° 30′, a″ : a″=143° 42′, Brooke. *Cleavage* parallel to M and P indistinct, more obvious parallel to ĕ. The crystals are sometimes large and well defined, but usually very minute, and occasionally appear in bunches diverging from a common point.

H.=2·5—3. G.=6·4. *Lustre* resinous. *Streak* greenish-white. *Color* deep verdigris or bluish-green; inclining to mountain green if the crystals are delicate. Translucent. *Fracture* uneven. Rather brittle.

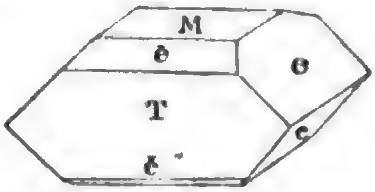
Brooke's analysis, (Edin. Phil. Jour. iii. 119,) determined its constituents to be

Sulphate of Lead	55·8
Carbonate of Lead	32·8
Carbonate of Copper	11·4=100.

OBS. It occurs only at Leadhills, in Scotland, accompanying the other ores of lead of that locality. It was first examined and described by Mr. Brooke.

CUPREOUS ANGLESITE. CRONALUS RHOMBOIDEUS.

Diplogenic Lead-Baryte, *Haid.* Cupreous Sulphate of Lead.



249. *Primary form:* a right rhomboidal prism; M : T=95° 45′, as determined by Haidinger. *Secondary form:* the annexed figure, e : e=119°, Haidinger. *Cleavage* very perfect parallel to M and T.

H.=2·5—3. G.=5·3—5·5. *Lustre* vitreous or adamantine. *Streak* pale-blue. *Color* deep azure-blue. Translucent.

According to Brooke, (Ann. of Phil. 2d ser. iv. 117,) it consists of Sulphate of Lead 74·4, Oxyd of Copper 18·0, and Water 4·7=97·1. In the blowpipe flame, it affords indications of copper and lead.

OBS. This mineral occurs only at Leadhills, but is even there an exceedingly rare mineral. Linares, in Spain, has been reported as another locality.

MINIUM.

250. Pulverulent, exhibiting, under the microscope, occasionally

crystalline scales. The crystal, according to M. Kapper, is a right rhombic prism of 93° 44′.

G.=4·6. *Color* vivid red, mixed with yellow.

According to Mr. Smithson, it is a Sesquoxyd of Lead. In the reduction flame of the blowpipe, globules of lead are obtained.

Obs. It occurs at Bleialf, in Eifeld; Badenweiler, in Baden; Brillon in Westphalia, island of Anglesia; and Grass-hill chapel, in Yorkshire. It is usually associated with galena, and also with calamine.

PLUMBIC OCHRE.

251. Occurs massive. G.=8·0. *Lustre* dull. *Streak* lighter than the color. *Color* between sulphur and lemon-yellow. Opaque. Does not soil.

Dr. John determined the following as its constituents: Protoxyd of Lead 87·382, Carbonic Acid 3·846, Oxyd of Iron and Lime 0·481, Ferruginous Silica 2·404=94·113. Melts easily before the blowpipe, and is easily reduced.

Obs. It is said to occur at Badenweiler, in Baden, in quartz. Geralt states that it has been ejected from the volcanoes of Popocatapetl and Jztaccituall, in Mexico.

POLYSPHÆRITE.

Breithaupt, Jahresbericht, 1832, p. 202.

252. In roundish masses; structure internally radiated.

H.=3—4. G.=5·83—5·89. *Lustre* greasy. *Fracture* conchoidal.

Contains Oxyd of Lead, Phosphoric Acid, and Magnesia.

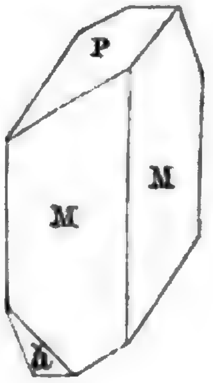
Obs. Occurs at the mines of Freiberg, in Saxony, associated with blende, galena, quartz, and iron pyrites.

APHANESITE. CYPRALUS ACROTOMUS.

Diatomous Habroneme-Malachite, *M.* Axotomous Habroneme-Malachite, *Haid.* Radiated Acicular Olivenite, *Jam.* Strahlerz, *Hoff.* Cuivre Arseniaté Ferrifère, *H.* Cuivre Arseniaté en Prism Rhomboidale Oblique, *Levy.*

253. *Primary form:* an acute oblique rhombic prism; M : M=56° and 124°, P : M=85° and 95°. *Secondary form:* M : M=124°, P : ă=99° 30′. *Cleavage* highly perfect parallel with P.

H.=2·5—3·0. G.=4·192. *Lustre* of face P pearly. *Streak* verdigris-green. *Color* dark verdigris-green, inclining to blue; also dark-blue. Subtranslucent. Not very brittle.



According to Chenevix and Richardson, it contains

Oxyd of Copper	54·00	56·65
Arsenic Acid	30·00	39·80
Water	16·00=100, C.	3·55=100, R.

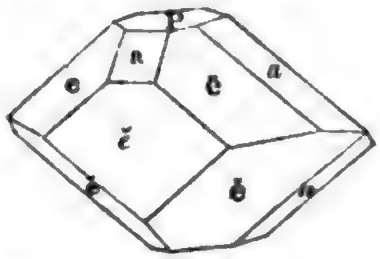
It deflagrates before the blowpipe, fuses readily, and emits arsenical fumes.

Obs. It occurs only at Cornwall, with other salts of copper. The crystals usually present a very dark-blue color and brilliant lustre, but are rarely recognizable, being aggregated in diverging groups, or disposed in extremely minute individuals, in cavities of quartz. Hence the name *Aphanesite*, from *αφανης, unmanifest.*

BLUE MALACHITE. Cypralus cœruleus.

Prismatic Azure-Malachite, *M.* Blue Copper Ore. Blue Carbonate of Copper. Hydro-Carbonate of Copper, *Thomson.* Chessy Copper.

254. *Primary form:* an oblique rhombic prism; M : M=98° 50′. *Secondary form:* P : ĕ=92° 21′. a : ĕ= 132° 43′, *a* : *a* (over P) =99° 32′. It occurs also massive, and presenting several imitative shapes, having a columnar composition; also of a dull and earthy appearance.



H.=3·5—4·25. G.=3·831. *Lustre* vitreous, almost adamantine. *Streak* blue, lighter than the color. *Color* various shades of azure-blue, passing into azure and Berlin-blue. Transparent—subtranslucent. *Fracture* conchoidal. Brittle.

It contains, according to Klaproth, (Beitrage iv. 31,) Vauquelin, (Ann. de Museum, xx. 1,) and Phillips, (Journ. Royal Institution iv. 276,)

Carbonic Acid	24·00	21·25	25·46
Oxyd of Copper	70·00	70·00	69·08
Water	6·00=100, K.	8·75=100, V.	5·46=100, P.

It blackens, when strongly heated, and, on charcoal, fuses; borax is colored green. It dissolves with effervescence in nitric acid.

Obs. Blue malachite occurs abundantly in splendid crystallizations, presenting a great variety of forms and brilliant colors, at Chessy, near Lyons, whence it has derived its name of *Chessy Copper.* It also occurs in fine crystals in Siberia; at Moldawa, in the Bannat; at Wheal Buller, near Redruth, in Cornwall; also in small quantities at Alston Moor and Wanlockhead.

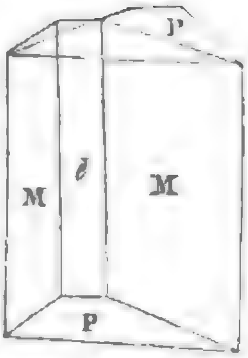
This mineral occurs at the Perkiomen lead mine, associated with galena, blende, and white lead ore; the specimens, however, are rather indifferent.

If abundant, blue malachite is a valuable ore of copper. It forms a blue paint of a bright tint, when ground to an impalpable powder; but is of little value as a pigment, on account of its liability to turn green.

GREEN MALACHITE. Cypralus vulgaris.

Hemi-Prismatic Habroneme-Malachite, *M.* Diprismatic Green Malachite, *Jameson.* Green Carbonate of Copper. Mountain Green. Atlaserz.

255. *Primary form:* an oblique rhombic prism; M : M=130° P : ĕ (plane truncating the first lateral edge) =118° 11′. *Cleavage* highly perfect parallel to P; less distinct parallel to ĕ, or the longer



diagonal. *Compound crystals:* composition of the second kind; parallel with the obtuse lateral edge of the prism. *Imperfect crystallizations:* in fascicular groups; tuberose, botryoidal, and stalactitic shapes, composed of diverging fibres; also fibrous; and frequently granularly massive, of an earthy appearance.

H.=3·5—4. G.=4·008, Haidinger. *Lustre* adamantine, inclining to vitreous; fibrous varieties have often a silky, and others an earthy lustre. *Streak* green, rather paler than the color. Translucent—subtranslucent—opaque. *Fracture* subconchoidal, uneven. Seldom observed in crystallized forms.

It contains, according to Klaproth, (Beitrage ii. 287,) and Vauquelin, (Haüy's Min. iii. 491,)

Carbonic Acid	18·0	21·25
Oxyd of Copper	70·5	70·00
Water	11·5=100, K.	8·75=100, V.

It is, therefore, a hydrous dicarbonate of copper.

Before the blowpipe, it decrepitates, becomes black, and is partly infusible, and partly converted into a black scoria. With borax, it fuses easily into a deep green globule, and ultimately affords a bead of copper. It dissolves with effervescence in nitric acid.

Green malachite usually accompanies the other ores of copper. Perfect crystals are quite rare. The fibrous variety occurs abundantly in Siberia; at Chessy, in France; and in the old mine at Sandlodge, in Shetland; the compact occurs at Schwatz, in the Tyrol. It also occurs at Cornwall.

In the United States, it occurs in connection with the vitreous copper of Cheshire, Conn.; at Schuyler's mines, New Jersey, where it is accompanied also with red copper ore; in the Blue Ridge, in Pennsylvania, near Nicholson's Gap; at the Perkiomen lead mine; but it has not been obtained at either of these and other localities in fine specimens.

Green malachite admits of a high polish, and when in large masses, is cut into tables, snuff-boxes, vases, &c.

CHRYSOCOLLA. CYPRALUS AMORPHUS.

Uncleavable Staphyline-Malachite, *M.* Copper-green. Silico-Carbonate of Copper, *Thomson.*

256. Botryoidal and massive.

H.=2—3. G.=2—2·238. *Lustre* vitreous, shining, earthy. *Streak* white. *Color* emerald- and pistachio-green, passing into sky-blue; often brown when impure. Translucent—translucent-opaque. *Fracture* conchoidal. Rather sectile; translucent varieties brittle.

It contains, according to Klaproth, (Beit. iv. 34,) John, and Thomson,

Silica	26	28·37	25·31
Oxyd of Copper	50	49·63	54·46
Carbonic Acid	07	3·00	14·98
Water	17	17·50	5·25
Sulphate of Lime	—=100, K.	1·50=100, J.	——100, T.

"The great difference in the proportion of carbonic acid in these analyses, renders it probable that the carbonate and silicate of copper are not chemically combined." Thomson.

It blackens in the interior flame of the blowpipe on charcoal, without melting. With borax it melts into a green glassy globule, and is partly reduced.

Obs. The same specimen of this mineral often presents very different appearances at its opposite parts; being sometimes of an earthy appearance, like decomposed feldspar, in one part, and translucent and brittle on the opposite. The differences of the several varieties are owing, more or less, to impurities.

It accompanies other copper ores, in Cornwall; at Libethen, in Hungary; at Falkenstein and Schwatz, in the Tyrol; in Siberia, the Bannat, Thuringia, &c.

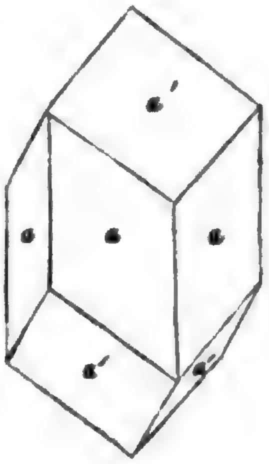
In Sommerville, New Jersey, chrysocolla occurs, associated with red copper ore, native copper, and green malachite; also with similar associated minerals and with brown iron ore in Nova Scotia, at the basin of mines.

DIOPTASE. Cypralus rhombohedrus.

Rhombohedral Emerald-Malachite, *M.* Emerald Copper. Achirite.

257. *Primary form:* an obtuse rhombohedron; R : R=126° 17′. *Secondary form:* fig. 118, *a′* : *a′*=95° 48′, *a′* : *a*=132° 6′, *a* : *a*=120°. *Cleavage* perfect, parallel with R.

H.=5. G.=3·278. *Lustre* vitreous—inclining to resinous. *Streak* green. *Color* emerald-green; also blackish-green, and verdigris-green. Transparent—subtranslucent. *Fracture* conchoidal, uneven. Brittle.



Its constituents have been determined very differently by different chemists. It contains, according to Lowitz, Vauquelin, and Hess,

Oxyd of Copper	55	25·57	45·10
Silica	33	28·57	36·85
Water	12	——	11·52
Carbonate of Lime	—	42·85	Lime 3·39
Alumina	—	——	2·36
Magnesia	—=100, L.	——=96·99, V.	0·22=99·44, H.

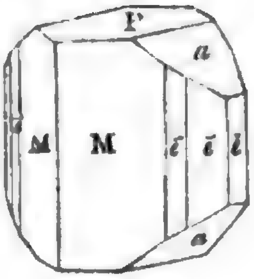
It decrepitates in the blowpipe flame, tinging it yellowish-green; in the exterior flame it becomes black, and in the interior red, but does not melt. It fuses with borax, giving it a green color, and finally is reduced. Insoluble in nitric, but soluble without effervescence in muriatic acid. It acquires negative electricity by friction when insulated.

Obs. Dioptase occurs disposed in well defined crystals on quartz, in the Kirghese Steppes of Siberia, whence it was first brought by a Bucharian merchant, Achir Mamed. It was named Achirite, after this merchant. It is said to occur at Rezbanya, in Hungary, associated with electric calamine.

EUCHROITE. Cypralus speciosus.

Prismatic Emerald-Malachite, *M.* Euchroite, *Breithaupt.*

258. *Primary form:* a right rhombic prism; M : M=117° 20′.



Secondary form : P : *a*=133° 56′, *ĕ* : *a*=136° 4′, M : ĕ=121° 20′. *Cleavage* parallel to M, distinct. Faces M vertically striated.

H.=3·75. G.=3·389. *Lustre* vitreous. *Streak* pale apple-green. *Color* bright emerald-green. Transparent—translucent. Doubly refracts distinctly. *Fracture* small conchoidal, uneven. Rather brittle.

According to Dr. Turner's analysis, (Schweigger's Jahrbuch, xv. 233,) it contains,

Peroxyd of Copper	47·85
Arsenic Acid	33·02
Water	18·80=99·67.

In the matrass, it loses its water, and becomes yellowish-green and friable. Heated on charcoal to a certain point, it is reduced in an instant with a kind of deflagration, leaving a globule of malleable copper, with white metallic particles disseminated throughout the mass, which volatilize with the continuance of the heat.

Obs. It occurs in quartzose mica slate at Libethen, in Hungary, where it is found in crystals of considerable size, having much resemblance to dioptase. Its trivial name is derived from *ευχροια*, *beautiful color.*

ERINITE. Cypralus concentricus.

Dystomic Habroneme-Malachite, *Haid.* Hydrous Sub-bisesquarsenate of Copper, *Thomson.*

259. Occurs in mammillated crystalline groups, consisting of concentric coats of a fibrous structure, and presenting rough surfaces, arising from the terminations of very minute crystals. The layers, which are themselves very compact, are often easily separable. They sometimes present indistinct traces of what appears to be a rectangular cleavage.

H.=4·5—5. G.=4·043. *Lustre* almost dull, slightly resinous. *Streak* green, paler than the color. *Color* a fine emerald-green, slightly inclining to grass-green. Subtranslucent—nearly opaque. Brittle.

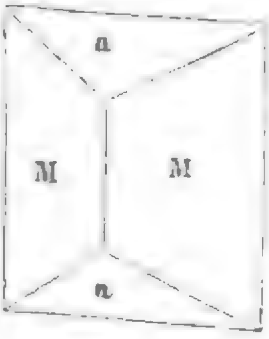
It is composed, according to Dr. Turner, (Phil. Mag. 2d ser. iv. 154,) of

Oxyd of Copper	59·44
Arsenic Acid	33·78
Alumina	1·77
Water	5·01=100, Turner.

Obs. Erinite occurs associated with other cupric arsenates, in the county of Limerick, Ireland. It was first described by Haidinger.

LIROCONITE. CYPRALUS RECTANGULUS.

Prismatic Lirocone-Malachite, *M.* Prismatic Olivenite, or Lenticular Copper, *Jam.* Octahedral Arseniate of Copper. Linsenerz, *Wern.* Linsenkupfer, *Haus.* Cuivre Arseniaté Octaèdre obtus, *H.*



260. *Primary form:* a rectangular octahedron or prism; M : M=60° 15′, and 119° 45′. *Secondary form:* a : a=71° 59′. *Cleavage* parallel with M, but with difficulty obtained. Massive granular varieties occur, but are rare.

H.=2—2·5. G.=2·882. Bournon; 2·926. Haidinger. *Lustre* vitreous, inclining to resinous. *Streak* and *Color* sky-blue—verdigris-green. *Fracture* imperfectly conchoidal, uneven. Nearly sectile.

According to Chenevix, this mineral contains Oxyd of Copper 49, Arsenic Acid 14, Water 35=98.

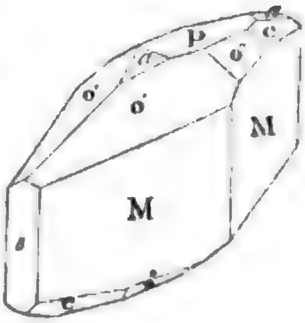
An analysis by Thomson of some pure crystals, though unsatisfactory, as he states, on account of the small quantity employed, gives a very different composition; according to him, it consists of Oxyd of Copper 30·10, Arsenic Acid 43·39, Water 26·69=100·18.

Before the blowpipe it loses its color and transparency, emits arsenical fumes, and becomes a black, friable scoria, containing some white metallic globules. With borax, it affords a green globule, and undergoes a partial reduction. It dissolves in nitric acid without effervescence.

OBS. Crystals of this mineral have rarely been observed an inch in diameter; usually they are quite small. It occurs associated with various ores of copper, pyrites, and quartz, at Huel Gorland and Huel Unity, in Cornwall; also in minute crystals at Herrengrund, in Hungary.

PSEUDO-MALACHITE. CYPRALUS HEMIHEDRUS.

Prismatic Habroneme-Malachite, *M.* Prismatic Olivenite. Phosphate of Copper. Hydrous Phosphate of Copper.



261. *Primary form:* a right rhombic prism; M : M=38° 56′. *Secondary form:* This crystal is hemihedrally modified, and consequently, it has the aspect of an *oblique* rhombic prism; P : ĕ=90°, M : M=141° 4′, the supplement of 38° 56′, M : ĕ=109° 28′. M and M being considered the primary lateral planes, o′ and o″ are intermediary planes on the obtuse solid angles; but if viewed as beveling planes of the obtuse lateral edge, and the plane o′ as replacing a basal edge P : M, o″ will replace the obtuse solid angle. In lettering the crystal according to this view of it, we should substitute ĕ′ for M, e′ for o′, a for o″, and o′ for e, which then becomes an intermediary. *Cleavage* appears merely in indistinct traces parallel to ĕ or the shorter diagonal; also it is stated parallel to *a*. *Imperfect crystallizations:* reni-

31

form shapes and massive, with an indistinctly columnar composition and drusy surface.

H.=4·75—5. G.=4·205. *Lustre* adamantine, inclining to vitreous. *Streak* green, a little paler than the color. *Color* emerald-green, verdigris-green, blackish-green, often darker at the surface. Translucent—subtranslucent. *Fracture* small conchoidal, uneven. Brittle.

It contains, according to Klaproth, (Beitrage, iii. 201,) and Lunn, (Ann. Phil. 2d ser. iii. 179,)

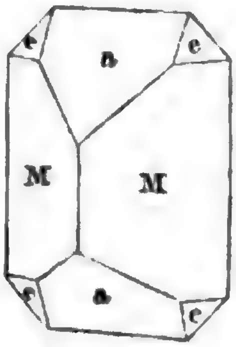
Oxyd of Copper	68·13	62·847
Phosphoric Acid	30·95	21·687
Water	——=99·08.	15·454=99·988.

It fuses readily in the blowpipe flame, into a small vesicular metalloidal globule. It dissolves without effervescence in nitric acid; more readily if heated.

Obs. Pseudo-malachite occurs in veins traversing gray-wacke slate at Rheinbreitenbach, near Bonn, on the Rhine, and is associated with quartz, and other ores of copper. The massive variety is met with at Libethen, in Hungary.

LIBETHENITE. Cypralus dystomus.

Diprismatic Olive-Malachite, *M.* Prismatic Olivenite. Phosphate of Copper. Hydrous Diphosphate of Copper, *Thom.* Cuivre Phosphaté, *H.*



262. *Primary form:* a right rhombic prism; M : M=95° 2′. *Secondary form:* a : a over the apex =111° 58′. *Cleavage* very indistinct parallel to M and a.

H.=4. G.=3·6—3·8. *Lustre* resinous. *Streak* olive-green. *Color* olive-green, generally dark. Subtranslucent. *Fracture* conchoidal, uneven. Brittle.

According to Berthier, (Ann. des Mines, viii. 334,) it consists of

Phosphoric Acid	28·7
Oxyd of Copper	63·9
Water	7·4=100,

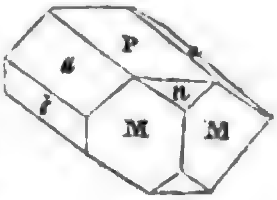
and, therefore, contains two parts of oxyd of copper to one of acid.

On the first impression of the heat of the blowpipe, it fuses into a brownish globule, which, by further action of the heat, acquires a reddish-gray color and metallic lustre, and ultimately yields at its centre, a globule of metallic copper.

Obs. It occurs in cavities in quartz, associated with copper pyrites at Libethen, near Neusohl, in Hungary; also in small quantities near Gunnislake, in Cornwall.

OLIVENITE. Cypralus acicularis.

Prismatic Olive-Malachite, *M.* Acicular Olivenite. Prismatic Arseniate of Copper, *Bournon.* Prismatic Oliven Ore. Olivenit, *L.*



263. *Primary form:* a right rhombic prism; M : M=110° 50′. *Secondary form:* P : *a*= 136° 15′, M : ĕ=124° 35′. *Cleavage* in traces parallel to M and *a*, the former a little the most distinct. *Imperfect crystallizations:* globular and reniform shapes, with indistinctly columnar

structure; individual columns straight and divergent, rarely promiscuous. Also fibrous, curved lamellar and granularly massive varieties occur.

H.=3. G.=4·2809, Bournon; 4·166, Richardson. *Lustre* adamantine—vitreous; of some fibrous varieties pearly. *Streak* olive-green—brown. *Color* various shades of olive-green, passing into leek-, siskin-, pistachio-, and blackish-green; also liver-, and wood-brown. Subtransparent—opaque. *Fracture* when visible, conchoidal, uneven. Brittle.

It contains, according to Kobell, (Poggendorf's Annalen, xviii. 249,) and Richardson, (Thomson's Min. i. 614.)

Arsenic Acid	36·71	36·9
Oxyd of Copper	56·43	56·2
Water	3·50	3·9
Phosphoric Acid	3·36=100, K.	——=100, R.

It, therefore, consists of two parts of oxyd of copper to one of acid.

Remains unaltered before the blowpipe alone, but on charcoal it fuses with a kind of deflagration, and yields a white metallic globule, which, as it cools, becomes covered with a red scoria. It dissolves in nitric acid.

Obs. The crystallized varieties occur disposed on, or coating cavities of quartz, at the Cornwall mines; also in inferior specimens at Alston Moor. The *wood arsenate*, is a term which has been applied to a variety presenting a soft velvet-like surface, and a light siskin or greenish-gray color, having an earthy texture, and a radiated or fibrous structure. It is peculiar to Cornwall.

ATACAMITE. CYPRALUS EXHALANS.

Prismatoidal Habroneme-Malachite, *M.* Hexmuriate of Copper, *Thomson.*

264. *Primary form:* a right rhombic prism; M : M=97° 20′. *Secondary forms:* a rectangular octahedron; this form is most commonly presented by its minute crystals. It also presents highly modified rectangular prisms. *Cleavage* parallel to P perfect; less indistinct parallel to M.

H.=2·5—3. G.=4·43. *Lustre* adamantine—vitreous. *Streak* apple-green. *Color* various shades of green, sometimes blackish-green. Translucent—subtranslucent.

It is composed, according to Proust, (Ann. de Chim. xxxii. 49,) and Klaproth, (Beitrage, iii. 200,) of

Oxyd of Copper	76·6	73·0
Muriatic Acid	10·6	10·1
Water	12·8=100, P.	16·9=100, K.

It is, therefore, a chlorid of copper; and is composed of 1 part of chlorine to 6 of copper and 6 of water.

It tinges the blowpipe flame a bright green or blue, and gives off fumes of muriatic acid; on charcoal, the copper is reduced to the metallic state.

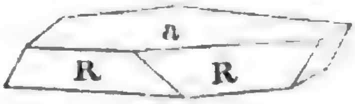
Obs. This species was originally found in the state of sand in the Atacama desert, between Chili and Peru. It is said to occur also at Remolinos, in Chili, and in veins in the district of Tarcpaca. It also invests some of the lavas of Vesuvius, being formed by the action of the volcano; Schwarzenberg, in Saxony, is another reported locality.

It is ground up in Chili, and sold under the name of Arsenillo, as a powder for letters.

COPPER MICA. Cypralus foliaceus.

Rhombohedral Euchlore-Mica, *M.* Prismatic Copper Mica, *J.* Rhomboidal Arsenate of Copper, *P.* Kupfer Glimmer, *W.* and *L.* Terhydrous Diarsenate of Copper, *Thom.*

265. *Primary form:* an acute rhombohedron; R : R=69° 30′. *Secondary form:* R : a=108° 40′. *Cleavage* highly perfect parallel to the plane a, whose surface is sometimes striated in triangular directions. It is said also to occur massive.



H.=2. G.=2·5488, Bournon. *Lustre* of a, pearly, of the other faces, vitreous. *Streak* somewhat paler than the color. *Color* emerald or grass-green. *Fracture* scarcely observable. Sectile.

It contains, according to Vauquelin and Chenevix,

Oxyd of Copper	39·00	58·00
Arsenic Acid	43·00	21·00
Water	17·00=99, V.	21·00=100, C.

It decrepitates in the blowpipe flame, loses its color and transparency, emits arsenical fumes, and fuses into a black globule, after forming a black spongy scoria.

Obs. The copper mines of Tingtang, Wheal Gorland, and Wheal Unity, near Redruth, are its principal localities in Cornwall. It is stated to have been observed in minute crystals in Herrengrund, in Hungary.

COPPER FROTH. Cypralus decrepitans.

Prismatic Euchlore-Mica, *M.* Cupriferous Calamine, *P.* Zinc Hydraté Cupriferè, *Levy.* Kupferschaum. Copper Schaum, and Hydrous Subbisesquarseniate of Copper, *Thom.* Borodiglione. Pharmacosiderite. Kupaphrite.

266. *Primary form:* a right rhombic prism. *Secondary form:* the primary, with the acute lateral edges truncated. *Cleavage* parallel with P perfect. Surface M with horizontal striæ.

H.=1—1·5. G.=3·098. *Lustre* of P pearly, of other faces vitreous. *Streak* a little paler than the color. *Color* pale apple-green, and verdigris-green, inclining to sky-blue. Translucent—subtranslucent. *Fracture* not observable. Very sectile. Thin laminæ are flexible.

It contains, according to Kobell's analyses, (Poggendorf's Annalen, xviii. 253,) of specimens from Falkenstein, in the Tyrol,

Arsenic Acid	25·01	25·366
Oxyd of Copper	43·88	43·660
Water	17·46	19·824
Carbonate of Lime	13·65=100.	11·150=100.

It decrepitates briskly in the blowpipe flame, throwing off fine fragments, which tinge the flame green, blackens, and fuses into a steel-gray globule, not crystalline on its suface. On charcoal, it emits moisture quietly, and after a long continuance of the blowpipe heat, swells a little from the extrication of the vapor of arsenic. With carbonate of soda, an imperfectly fluid mass is obtained, which contains a white metallic nucleus.

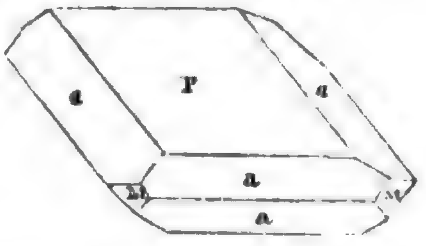
Obs. This mineral usually occurs in the cavities of calamine, calc spar, or quartz, and accompanied by other ores of copper, appearing in small aggregated and diverging fibrous groups of a pale-green color, and possessing a delicate silky lustre. It has been observed in the Bannat; at Libethen, in Hungary; Nerzschinsk, in Siberia; Schwartz, in the Tyrol; Saalfield, in Thuringia; and Matlock, in Derbyshire.

BROCHANTITE.

Levy, Ann. of Phil. VIII. 241. 1824.

267. *Primary form:* a right rhombic prism; M : M=114° 20′. *Secondary form:* the annexed figure; P : *a*=148° 30′, *a* : *a* (over P) =117°, a : a (adjacent planes) =150° 30′, P : a =104° 45′. Surface M blackish, and dull. *Cleavage* in traces parallel with M.

H.=3·5—4. G.=3·7—3·8. *Lustre* vitreous. *Color* emerald-green. Transparent.



According to Children, (Ann. of Phil., 2d ser., viii. 241,) it consists of Sulphuric Acid, Oxyd of Copper, and a little Silica, or Alumina. It dissolves in muriatic acid, and blackens before the blowpipe, without fusing.

A mineral from Rezbanya, in Hungary, analyzed by Gusaav Magnus, of Berlin, appears to be closely allied to this species. He obtained for its composition Sulphuric Acid 17·426, Oxyd of Copper 66·935, Water 11·917, Oxyd of Tin 3·145, Oxyd of Lead 1·048. With this species, must also be united the *Konigine* of Levy.

Obs. It occurs in small but well defined crystals, with malachite, and native copper, at Ekatherinenburg, in Siberia. The Konigine was found at the same locality.

VELVET COPPER ORE.

Cuivre Velouté, *Levy*. Kupfersammterz.

268. Occurs in short delicate fibres, diverging from a centre, and gregagated in spherical globules. *Color* a fine smalt-blue.

Obs. It occurs sparingly at Moldawa, in the Bannat, coating the cavities of an earthy oxyd of iron. From its rarity, the characters of the species have not been accurately determined.

NICKEL GREEN. Niccalus prasinus.

Diarseniate of Nickel, *Thom.*

269. In capillary crystals; also massive.

Soft. *Color* a fine apple-green. *Streak* greenish-white. *Fracture* uneven, or earthy.

According to Berthier, (Ann. de Ch. et de Ph. xiii.,) it contains

Arsenic Acid	37·29	36·8
Oxyd of Nickel	36·49	36·2
Water	26·22	25·5
Oxyd of Cobalt	——=100.	2·5=100.

Darkens in color before the blowpipe. On charcoal, it gives out the odor of arsenic, and in the inner flame of the blowpipe yields a metallic button.

Obs. It occurs on white nickel at Allemont, in Dauphiny, and is supposed to result from the decomposition of this ore.

HERRERITE. Niccalus Herreri.

270. Massive; reniform. *Cleavage* in three directions, indicating a rhombohedral primary. Surface curved.

H.=4—5. G.=4·3. *Lustre* vitreous to pearly; shining on fresh surfaces. *Streak* yellowish-gray. *Color* pistachio,- emerald-, and grass-green. Translucent.

According to Herrera, it contains Carbonic Acid 31·86, Tellurium 55·58, Peroxyd of Nickel 12·32. On charcoal, it becomes gray under the action of the blowpipe, and evolves a white smoke which adheres to the charcoal. In the reducing flame it is changed to a beautiful grass-green. Heated in an open tube, it gives an abundant smoke, which adheres to the glass, and on examination with a microscope, appears to be composed of innumerable white transparent globules.

Obs. It occurs at Albarradon, in Mexico, in transition limestones, in a metallic vein, consisting chiefly of ores of lead, native silver, horn silver, and iodic silver.

URANIC OCHRE. Uranalus ochraceus.

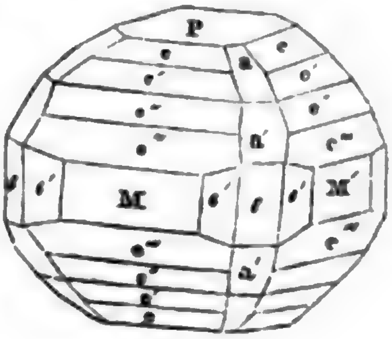
271. Earthy and pulverulent. *Color* sulphur-yellow, citron-yellow to brownish or reddish-yellow. When gently heated, it becomes orange-yellow.

It is believed to be Carbonate of Uranium. It effervesces in acid, yielding a yellow solution, which affords a brown precipitate with prussiate of potash.

Obs. It accompanies pitchblende, in Cornwall, and in Bohemia.

URANITE. Uranalus quadratus.

Pyramidal Euchlore-Mica, ***M.*** **Pyramidal Uranite,** ***J.*** **Uran Mica. Cupreo-phosphate of Uranium,** ***Thom.*** **Chalcolite-Uranglimmer,** ***W.*** **Uranoxyd,** ***Haus.*** **Urane Oxydé,** ***H.***



272. *Primary form:* a right square prism. *Secondary*: similar to figs. 52 and 53. Pl. I.; also the annexed figure, P : e=145° 32′, P : e′=140° 40′, P : e″=137° 10′, P : e‴=111° 50′, P : a′=134°, Phillips. *Cleavage* parallel to P highly perfect; traces of *e*. Surface P smooth, M rough.

H.=2—2·5. G.=3·12, Champeaux. *Lustre* of P pearly, of other faces adamantine.

Streak somewhat paler than the color. *Color* emerald-green, grass-green, sometimes leek-green, apple-green or siskin-green; also gold-yellow, and lemon-yellow. Transparent—subtranslucent. *Fracture* not observable. Sectile. Laminæ brittle and not flexible. In this respect, this mineral differs from some green varieties of mica which it sometimes resembles.

It contains according to Berzelius, and R. Phillips,

	Cornwall.	Autun.	Cornwall.
Phosphoric Acid	14·62	14·96	16·0
Oxyd of Uranium	62·52	64·03	60·0
Oxyd of Copper	8·12	——	9·0
Water	14·74	15·04	14·5
Lime	——	5·97	——
Silica	——=100, B.	——=100, B.	0·5=100, P.

Specimens from Cornwall usually exhibit traces of arsenic and fluoric acids; those from Autun, of fluoric acid and ammonia.

Before the blowpipe, *per se*, it becomes yellow and opaque. It intumesces on charcoal, loses about one third by ignition, and fuses into a black globule, exhibiting traces of crystallization upon the surface. With borax, it forms a yellowish-green glass.

In nitric acid it dissolves without effervescence, forming, when the acid is saturated and the mineral is pure, a lemon-yellow solution.

Obs. Uranite is found with other ores of uranium, associated with silver, tin, and iron ores; occasionally also in beds.

Gunnis Lake formerly afforded splendid crystallizations of this mineral; and also more latterly, Tincroft, and Wheal Buller, near Redruth, in Cornwall. The siskin-green variety occurs in granite veins at St. Symphorien, near Autun, and at St. Yrieix, near Limoges, in France. It occurs also in the districts of Schneeburg and Johanngeorgenstadt.

ORDER III. CERATINEA.

HORN SILVER. CERATUS CUBICUS.

Hexahedral Pearl-Kerate, *M.* Muriate of Silver. Chlorid of Silver. Hornerz, *Wern.*, *Hoff.* Hornsilber, *Haus.* Argent Muriaté, *H.*

273. *Primary form:* the cube. *Secondary forms:* figs. 2, 3, 4, 5, 6, 7, Pl. I. *Cleavage* none. *Imperfect crystallizations:* usually a strongly coherent granular structure, rarely columnar, or bent columnar; often in crusts.

H.=1—1·5. G.=5·552. *Lustre* resinous, passing into adamantine. *Streak* shining. *Color* pearl-gray, passing into lavender-, and violet-blue; also into grayish-, yellowish-, and greenish-white, and into siskin-, asparagus-, pistachio-, and leek-green. Becomes brown on exposure. Translucent—feebly subtranslucent. *Fracture* more or less perfectly conchoidal. Sectile.

Klaproth analyzed a specimen from Saxony, and another from Peru, and obtained the following composition: (Beitrage, i. 132, and iv. 10.)

Silver	67·75	76
Chlorine	21·50	24
Oxyd of Iron	6·00	—
Alumina	1·75	—
Sulphuric Acid	0·25=97·25.	—=100.

The flame of the candle is sufficient to produce fusion, and an emission of fumes of muriatic acid. On charcoal it is easily reduced; and also if rubbed with a plate of moistened zinc or iron, the surface of zinc or iron becomes covered with a thin film of metallic silver. It is not soluble in nitric acid or water.

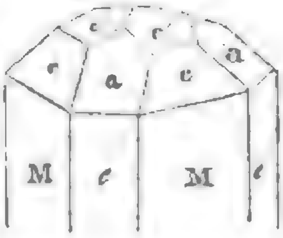
OBS. Horn silver occurs in veins in clay slate, accompanying other ores of silver, and usually only in the higher parts of these veins. It also has been observed with ochry varieties of brown iron ore; also with several copper ores, calcareous and heavy spar, &c.

The largest masses, and particularly those of a green color, are brought from Peru and Mexico, where it is associated with native silver. It was formerly obtained in the Saxon mining districts of Johanngeorgenstadt and Freiberg, but is now rare. A mass, weighing six and three-quarter pounds, from this locality, is now in the Zwinger collection, at Dresden. It also occurs in Siberia; at Kongsberg, in Norway; in Cornwall, and at Huelgoet, in Brittany: also at Andreasberg, in the Hartz, occurs an earthy variety, called by the Germans, Buttermilcherz, which, according to Klaproth, contains Silver 24·64, Muriatic Acid 8·28, Alumina 67·08.

Horn Silver, when found in large quantities, is valuable as an ore of silver.

HORN QUICKSILVER. CERATUS QUADRATUS.

Pyramidal Pearl-Korate, *M.* Muriate of Mercury. Dichlorid of Mercury, *Thom.* Native Calomel, *Haid.*



274. *Primary form:* a right square prism. *Secondary form:* M : *e*=135°, M : e=158°, M : e′=129° 32′, *e* : a=120° 5′. *Cleavage* parallel with M very indistinct. Occurs also in crystalline coats, and of a granularly massive structure.

H.=1—2. G.=6·482, Haidinger. *Lustre* adamantine. *Streak* white. *Color* yellowish-gray, or ash-gray, also grayish and yellowish-white. Translucent—subtranslucent. *Fracture* conchoidal. Sectile.

Klaproth found it to contain Oxyd of Mercury 76, Hydrochloric Acid 16·4, Sulphuric Acid 7·6. Artificial calomel is composed of Mercury 84·74, and Chlorine 15·26; or two parts of Mercury to one of Chlorine.

It is entirely volatilized on charcoal before the blowpipe, if pure, and is thus distinguished from the preceding species. It is insoluble in water.

OBS. This mineral is of even rarer occurrence than horn silver. Its principal locality is Moschellandsberg, in Deuxponts, where it occurs coating the cavities of a ferruginous gangue, and associated with cinnabar. The crystals are often large and well defined. It has also been observed at the quicksilver mines of Idria, in Carniola; at Almaden, in Spain; and at Harzowitz, in Bohemia.

IODIC SILVER. CERATUS FOLIATUS.

275. Structure foliated.

Soft. *Lustre* resinous. *Streak* semi-metallic. *Color* white—yellowish-green, with some black portions of metallic silver, which have a silver-white color when polished. Translucent. Plates flexible.

Some experiments by Vauquelin, determined that it contained Silver, Lead, Iron, Iodine, and Sulphur.

Before the blowpipe, on charcoal, it fuses immediately, producing a vapor which tinges the flame of a fine violet color, and affording some globules of silver.

OBS. Iodic Silver occurs in thin veins in steatite, at Abarradon, near Mazapil, in Mexico. It was first recognized by Vauquelin, (Ann. de Ch. et de Ph. xxix. 99,) among some specimens which M. Joseph Tabary brought from that country.

ORDER IV. OSMERINEA.

HALLOYLITE. Hydrolus cerinus.

Halloysite, *Berthier*. Ann. de Chim. et de Ph. XXXII. 334, and IX. 3d ser. 500.

276. Compact, and having the aspect of steatite.

Yields to the nail, and may be polished by it. G.=1·8—2·1. *Lustre* waxy. *Streak* white. *Color* white, generally with a bluish tint. Subtranslucent. *Fracture* conchoidal, like that of wax. Adheres to the tongue. When small pieces are put in water, they become transparent, like hydrophane; air is disengaged, and they increase in weight.

It contains, according to Berthier,

	Liege.	Bayonne.
Silica	39·5	46·7
Alumina	34·0	36·9
Water	26·5=100.	16·0=99·6.

When calcined, it loses one-fourth of its weight, and becomes milk-white. It is readily dissolved by sulphuric acid, which unites with the alumina, and leaves the silica in a gelatinous state.

Obs. Occurs with ores of zinc, iron, and lead, near Liege, and Lamur. Also at Housscha, near Bayonne. It was first described by Berthier, and named in compliment to its discoverer, M. Omalius d' Halloy. According to Brongniart, it results from the decomposition of a graphic granite.

The *Lenzinite* of John, from Kall, in the Eifeld, in Prussia, the *Severite*, of Dufour, from St. Sever, in France, and the *Pholerite*, which appears in the form of soft nacreous scales of a white color, from the coal formation of Fins, in the Dep. of Alliesin, France, are similar compounds with the above, and probably mere varieties of it.

KOLLYRITE. Hydrolus argilliformis.

Alumine Hydraté Silicifère, *Levy*. Hydrous Trisilicate of Alumina, *Thom*.

277. Massive; resembling clay in its general appearance.

Light and friable; H. sometimes as high as 3. *Lustre* of the surface of fracture vitreous. *Color* snow-white. Translucent—opaque. Adheres to the tongue. Hardly soils the fingers. *Fracture* earthy.

According to Klaproth, (Beitrage, i. 257,) and Berthier, (Ann. des Mines, ii. 476,) it contains,

	Schemnitz.	Esquerre.
Silica	14	15·0
Alumina	45	44·5
Water	42=101, K.	40·5=100, B.

Before the blowpipe it remains unaltered. When calcined, it gives off much water, separates into columnar masses like starch, and loses weight; it then will absorb water with a slight noise, and become partly transparent. Dissolves without effervescence in nitric acid, forming a saline magma without crystals.

Obs. This species was discovered by M. Lelievre, on the mountain Esquerre, in the French Pyrenees. It was afterwards found in the Shaft of Stephanus, at Schemnitz, in Hungary.

SCARBROITE. Hydrolus adhærens.

278. Massive. G.=1·48. Without *lustre*. *Color* pure white. *Fracture* conchoidal. *Odor* argillaceous when breathed on. Highly adhesive to moist surfaces; admits of being polished by the nail. When immersed in water, it does not become translucent or subtranslucent, neither does it fall to pieces; but it increases in weight.

It contains, according to Vernon, Alumina 42·75, Silica 7·90, Water 48·55, Peroxyd of Iron 0·80=100.

Obs. It occurs between laminæ of oxyd of iron, in a calcareous rock on the coast of Scarbro.

PYRARGILLITE. Hydrolus pyrosmicus.

Nordenskiöld, Jahresbericht, 1833, p. 174.

279. Massive; occasionally presenting the form of a four sided prism, with truncated angles or beveled edges; frequently traversed with minute chlorite particles. *Color* partly black and shining, or bluish and dull. Emits an argillaceous odor.

Consists of Silica 43·93, Alumina 28·93, Oxyd of Iron 5·30, Magnesia, with a little Oxyd of Manganese 2·9, Potash 1·05, Soda 1·85, Water 15·47=99·43. It is entirely soluble in nitric acid.

Obs. Occurs in granite, near Helsingsfors, in Finland. It was named as above by Nordenskiöld, on account of its argillaceous odor when heated, from πῦρ, *fire*, and ἄργιλλος, *clay*.

GIBBSITE. Hydrolus Gibbsianus.

280. Occurs in stalactitic forms, often irregular and small, forming a tuberose surface. Structure fibrous, the fibres radiating from the central column.

H.=3—3·5. G.=2·091, Thomson; 2·4, Torrey. *Lustre* faint. *Streak* white. *Color* grayish, or greenish-white. Translucent.

According to Dr. Torrey, (New York Med. and Phys. Journ. i. 68,) it is composed of Alumina 64·8, Water 34·7. Dr. Thomson gives the following composition as the result of his analysis, which may have been obtained from a less pure specimen: Alumina 54·91, Water 33·60, Silica 8·73, Peroxyd of Iron 3·93=101·17.

Obs. It has been found in small quantities in a bed of brown iron ore at Richmond, Mass., where it was first discovered by Dr. Emmons.

ALLOPHANE. Hydrolus tinctus.

Riemannite.

281. Reniform and massive; sometimes presenting traces of crystallization on the surface; occasionally almost pulverulent.

H.=3. G.=1·852—1·889. *Lustre* vitreous, or resinous; splendent and waxy internally. *Streak* white. *Color* pale-blue; sometimes green, brown, or yellow. Translucent. *Fracture* conchoidal, and shining. Very brittle.

The following is its composition, according to Stromeyer (Gilbert's Annalen, liv. 120,) Walchner, and Berthier, (Ann. des Mines, 1836, ix. 499.)

					Transparent variety.	Pulverulent variety.
Alumina	32·202		38·76		29·2	34·2
Silica	21·922		24·11		21·9	26·3
Water	41·301		35·75		44·2	38·0
Carb. of Copper	3·058	Ox. Cop.	2·33	Mixed clay,	4·7	1·5
Lime	0·730		——		——	——
Sulph. of Lime	0·517		——		——	——
Hyd. Perox. Iron	0·270=100, S.		——=100·95, W.		——=100, B.	——=100, B.

The heat of the blowpipe speedily deprives it of its color, and renders it opaque and pulverulent, producing at the same time some intumescence, and tinging the flame green. It does not fuse *per se*, but with borax melts readily into a transparent and nearly colorless glass. It forms a jelly with acids.

Obs. It occurs, lining irregular cavities in a kind of marl, at Saalfield, in Thuringia; at Schneeberg, in Saxony; and elsewhere. The specimens analyzed by Berthier, occur abundantly in the chalk of Beauvais, France; they presented a honey-yellow color. It was first observed by Messrs. Riemann and Roepert, and hence has been called *Riemannite*, The first analysis and description were made by Hoffman and Stromeyer, in 1816.

The name of this species is derived from αλλος, *other*, and φαινω, *to appear;* in allusion to its change of appearance under the blowpipe.

BOLE.

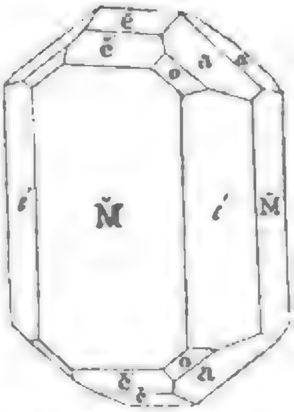
282. Massive; structure impalpably granular.

G.=1·6—1·97. Soft, or very soft. *Lustre* dull, or faintly glimmering. *Streak* shining, or resinous. *Color* brown, yellow, or red. Subtranslucent—opaque. *Fracture* perfectly conchoidal. *Feel* greasy. Adheres to the tongue. Thrown into water, it emits a crackling noise, and falls to a powder.

Obs. Bole occurs in irregular beds, or disseminated nodules in wacke and trap tufa, in Habitschwald, in Hessia; at Striegau, in Silesia; and at Sheibenberg, in Saxony.

SERPENTINE. OPHITIS COMMUNIS.

Hydrous Sesquisilicate of Magnesia, *Thom.* **Marmolite*** **of** *Nuttall.* **Deweylite,** *Emmons.* **Οφιτης, Ophitis,** *Vetruvius.* **Talcum Serpentinum,** *Linn., Wern.*



283. *Primary form:* a right rectangular prism. *Secondary form:* M̄ : e′=131° 14½′, e′ : e′=82° 27′, M̆ : ĕ=115° 44′, M : ĕ′=133° 58′, a : a=105° 26′. *Cleavage* indistinct parallel to M̆ and e′, apparent only in a strong light. Occurs usually massive; composition granular and impalpable. Some varieties have a lamellar structure.

H.=3—4. G.=2·507; 2·591, Thomson. *Lustre* resinous—greasy; low degrees of intensity. *Streak* white, slightly shining. *Color* leek-green and blackish-green; occasionally, lighter shades of oil and siskin-green colors; none bright. On exposure, it often becomes yellowish-gray. Translucent—opaque. *Fracture* conchoidal or splintery. Sectile.

It contains, according to Lychnell, Hisinger, Mosander, Vanuxem and Shepard,

Silica	41·58	41·95	43·07
Magnesia	42·41	40·64	40·37
Water	11·29	11·68	12·45
Lime	——	——	0·50
Alumina	trace	0·37	0·25
Protoxyd of Iron	2·17	2·22	1·17
Carbonic Acid	2·38=99·83, L.	3·42=100·28, L.	——=97·81, H.

Silica	42·34	42·69	40·08
Magnesia	44·20	40·00	41·40
Water	12·38	16·45	15·67
Protoxyd of Iron	0·18	1·00	2·70
Carbonic Acid	0·87=99·97, M.	——=100·14, V.	——=99·85, S.

The first is an analysis of a yellow translucent serpentine from Sjögruvan, in Svärdsjo. The second, of a precious serpentine from Skyttgruvan, at Fahlun; the third, from the same locality; the fourth, of an almost colorless variety from the limestone quarry of Gullsjo, in Wermeland; the two following, of marmolite, from Hoboken; the last of the same variety from Blanford.

On exposure to heat it gives off water, assumes a brownish red-color, but fuses with difficulty and only on the edges. With borax it forms a green-glass, which becomes nearly white on cooling. With carbonate of soda, it fuses into a yellowish-brown enamel

OBS. The translucent varieties of serpentine have been distinguished by the epithet *precious* or *noble serpentine*. *Common* serpentine has a more earthy aspect, and is only subtranslucent or opaque. The marmolite variety has a lamellar structure, and presents a dark or light-green, and greenish or bluish-white color. Its hardness is 2·5—3. Serpentine frequently forms mountain masses in primitive regions.

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* Silliman's Am. Journal, iv. 18.

Dark-green opaque crystals of serpentine have been observed in the Fassa valley, Tyrol; their form is, however, usually so imperfect, that but a few of the faces in the above figure are presented in the same individual. They have been considered pseudomorphs, and quite lately, M. A. Quernstedt, (Annalen der Physik, etc., 1835, No. 11,) has advanced the hypothesis, and supported it by very plausible arguments, that they are pseudo-crystals of chrysolite. For an explanation of the probable process in this transformation, see § 55.

The finest precious serpentines come from Fahlun and Gulsjo, in Sweden; the Isle of Man; the neighborhood of Portsoy, in Aberdeenshire; Corsica; Siberia; Saxony. Common serpentine occurs at Lizzard's Point, in Cornwall, and many other places.

In the United States, precious serpentine, of a light-green color, occurs at Phillipstown, in the Highlands, N. Y., where it is frequently intersected with narrow seams of asbestus; also at Newburyport, Mass., and at Newport, R. I. Near New Fane, Vt., and Middlefield, Mass., there are extensive formations of serpentine. At Amity, N. Y., and at Bryan, N. J., crystallized varieties have been observed disseminated through limestone, associated at the former place with black spinel and Ilmenite; at the latter with red spinel. The marmolite variety occurs with native magnesia, at Hoboken, N. J., and at Blandford, Mass., with schiller spar. A compact variety of serpentine, in many respects resembling the marmolite, has been found in seams and irregular veins, at Middlefield, Mass., at Cooptown, Hartford Co., Md., and at Amity, N. Y. Specimens of precious serpentine are also obtained at the New Haven marble quarry, where it occurs in the verd antique marble of that region.

A mineral has been described by Hausmann under the name of *picrolite*, whose composition is very similar to that of serpentine. We would, therefore, connect it with this species, till farther crystallographic observations show an identity to be impossible. Its description is as follows: structure massive or fibrous. H.=3·5—4; color leek-green, passing into yellow. Streak a little shining—subtranslucent to opaque. The following are a few of its analyses.

	Stromeyer.	Lynchnell.	Almroth.
Silica	41·660	40·98	40·04
Magnesia	37·159	33·44	38·80
Water	14·723	12·86	9·08
Alumina	——	0·73	——
Protox. Iron	4·046	8·72	8·28
Protox. Mang.	2·247	——	——
Carbonic Acid	——=99·835.	1·73=98·46.	4·70=100·90.

Serpentine admits of a high polish, and from its softness, may be turned in a lathe. It is, therefore, sometimes employed as a material for ornaments, as vases, boxes, &c. At Zöblitz, in Saxony, Bayreuth, and in Franconia, several hundred persons are employed in this manufacture.

Chromate of iron is usually found disseminated through serpentine, giving it frequently a variegated appearance, somewhat similar to the skin of a snake. From this peculiarity it received its name, *serpentine* and *ophite*.

AGALMATOLITE. OPHITIS FIGULARIS.

Figure Stone. Bildstein, *W.* and *L.* Koreite. Lardite. Pagodite. Talc Graphique, *H.*

284. Massive; structure sometimes slaty.

H.=2; yields to the nail. G.=2·815, Klaproth; 2·895, Thomson. *Lustre* waxy, nearly dull. *Streak* white or grayish-white, somewhat shining. *Color* white, greenish, grayish, yellowish, brownish; rarely also pink and mottled. Subtranslucent—nearly opaque. *Fracture* coarse splintery. Sectile. *Feel* greasy.

It contains

	Vauquelin	Klaproth.	John.	John.	Thomson.
Silica	56	55	55	51·5	49·816
Alumina	29	33	30	32·5	29·596
Lime	2	—	1·75	3·9	6·000
Protox. Iron	1	0·5	1	1·75	1·500
Protox. Mang.	—	—	trace.	1·2	—
Potash	7	7	6·25	6·0	6·800
Water	5	3	5·5	5·13	5·5

The specimens analyzed by the above chemists were from China. Klaproth obtained very nearly the same result with a specimen from Nagyag.

Before the blowpipe it whitens, but is infusible. With borax, it affords a colorless glass. It dissolves in part in sulphuric acid, leaving a siliceous residue.

Obs. Agalmatolite occurs principally in China, where it is carved into grotesque images or pagodas, and chimney-piece ornaments. It is found also at Nagyag, in Transylvania; in Norway and Wales, in less characteristic varieties.

KEROLITE. Ophitis reniformis.

285. In kidney-shaped or reniform masses. Structure lamellar and compact.

H.=2—2·25. G.=2—2·2. *Lustre* vitreous, or resinous. *Streak* white. *Color* white, green. Transparent—translucent. *Fracture* conchoidal. *Feel* greasy; does not adhere to the tongue.

It contains, according to Pfaff,

Silica	37·95
Alumina	12·18
Magnesia	16·02
Water	31·00=97·15

Kerolite occurs at Frankenstein, in Silesia; and at Zöblitz, in Saxony; associated at each locality with serpentine.

A variety, *Dermatin*, is described by Briethaupt, as occurring on serpentine at Waldheim, in Saxony, in reniform, rarely globular masses, and also in thin coatings and crusts. H.=2. G.=2·136. *Lustre* resinous. *Streak* straw- or pea-yellow. *Color* different shades of green; also dark liver-brown. Subtranslucent. *Fracture* conchoidal. *Feel* greasy. *Odor*, when moistened, argillaceous.

KILLINITE.

286. Occurs in irregular thin crystals, apparently rectangular prisms; also in crystalline masses.

H.=4. G.=2·65—2·75. *Lustre* vitreous, weak. *Streak* yellowish-white. *Color* greenish-gray, often tinged brown by oxyd of iron, or from decomposition. Faintly translucent.

It contains, according to Barker, Lehunt, and Blythe,

	Barker.	Lehunt.	Blythe.
Silica	52·49	49·08	47·925
Alumina	24·50	30·60	31·041
Potash	5·00	6·72	6·063
Water	5·00	10·00	10·000
Protox. Iron	2·49	2·27	2·328
Lime	—	0·68	0·724
Magnesia, with Mang.	—	1·08	0·459
Protox. Manganese	0·75=90·24.	— =100·43.	1·255=99·795.

It bleaches before the blowpipe, intumesces, and fuses with little difficulty into a white enamel; with carbonate of soda, it fuses into a transparent glass.

Obs. Killinite occurs at Killiney Bay, near Dublin, where it exists in granite veins, near their junction with mica slate. Its associate minerals at the locality are spodumene, quartz, feldspar, and garnet. Its crystals have sometimes a length of four inches or more, and a breadth and thickness of about an inch. They closely resemble spodumene in their external appearance.

PYRALLOLITE.

Tersilicate of Magnesia, *Thom.*

287. *Primary form:* an oblique rhomboidal prism; P : M=140° 49′, M : T=94° 36′. *Secondary form:* with the obtuse lateral edge replaced. *Cleavage* distinct parallel to M and T; also in the direction of ē. Usually massive, with a granular composition.

H.=3·5—4. G.=2·555—2·594. *Lustre* dull, sometimes slightly resinous. *Streak* white. *Color* white, sometimes greenish. Subtranslucent—opaque. *Fracture* earthy.

The following composition was obtained by Nordenskiöld:

Silica	56·62
Magnesia	23·38
Alumina	3·38
Lime	5·58
Protoxyd of Mang.	0·99
Perox. of Iron	0·09
Water	3·58
Bitumen, and loss	6·38=100.

Before the blowpipe, it first becomes black, then white again; afterwards it intumesces, and melts on the edges into a white enamel. With borax, it yields a transparent glass. With soda, it fuses easily into a transparent yellowish-green glass. With biphosphate of soda, there is a slight effervescence, but fusion is obtained with great difficulty.

Obs. The only known locality of pyrallolite is at Storgord, in the parish of Pargas, in Finland, where it occurs in a limestone bed, with feldspar, pyroxene, scapolite, moroxite, and sphene. It was discovered by Count Steinheil, and first described and analyzed by Nordenskiöld. Its name is from the Greek πυρ, *fire*, αλλος, *other*, and λιθος, *stone*, in allusion to the change of color it experiences in the heat of the blowpipe.

HYDROUS SILICATE OF MAGNESIA.

288. There are several compounds which may come under the above general name, whose titles to the rank of species are not fully determined. They are as follow:

Sea Foam; called also *Meerschaum*, and *Magnesite*. The specimen from Coulommiers, thirty miles east of Paris, analyzed by Berthier, was soft, impressible by the nail; had a smooth and unctous feel, and a grayish-white, and occasionally slightly reddish color; when immersed in water, it imbibed it readily, and increased in bulk, and finally formed a soft paste, without plasticity, similar to jelly. It contained Silica 54, Magnesia 24, Water 20·1, Alumina 1·4. When heated, it loses its grayish or reddish tint, and becomes white.

Meerschaum of Thomson. It occurs at Eski Scheher, in Natolia, in a large fissure six feet wide in calcareous earth. H.=2. *Lustre* dull. *Color* white. Opaque. *Fracture* fine, earthy. Surface smooth. It contains Silica 42, Magnesia 30·5, Water 23, Lime 2·3, Alumina with a trace of Manganese 2=99·8. Heated, it gives out water and a fetid odor, becomes hard and perfectly white. It is employed for the manufacture of the bowls of Turkey tobacco pipes, and thus supports a monastery of Dervises, established near where it is dug. The workmen assert that it grows again in the fissure, and puffs itself up like froth.

Quincite, of Berthier, is a red colored substance, which is disseminated through a limestone deposit, extending from Mehun, in France, beyond the village of Quincey. It may be obtained pure from the limestone, by treating it with acetic or dilute muriatic acid. It is in light particles of a carmine-red color; this color is removed by heat, which at the same time evolves water. It contains Silica 54, Magnesia 19, Protoxyd of Iron 8, Water 17=98. It is acted on imperfectly by the strong concentrated acids, which dissolve the magnesia and iron, and leave the silica in a gelatinous state.

PINITE. STYLUS HEXAGONUS.

Micarelle, *Kirwan.*

289. *Primary form:* a hexagonal prism. *Secondary form:* the primary with its lateral edges truncated or beveled; often the bevelment is so far extended as to produce twelve sided prisms. *Cleavage* is sometimes apparent parallel to the base of the prism; usually very indistinct.

H.=2·25. G.=2·7575, C. G. Gmelin, a variety from St. Pardoux; 2·782, Haidinger, crystallized specimen from France. *Lustre* resinous, inclining to pearly; glistening. *Streak* white. *Color* gray, grayish-green, or brown. Opaque. *Fracture* uneven.

It contains, according to Gmelin's analysis of a specimen from St. Pardoux,

Silica	55·964
Alumina	25·480
Potash	7·894
Soda	0·386
Peroxyd of Iron	5·512
Magnesia, with Manganese	3·760
Water	1·410=100·406.

Before the blowpipe it whitens and fuses on the edges, but does not melt. With borax it yields, after a continued blast, a transparent globule, colored by iron.

A variety from Saxony is entirely unalterable under the blowpipe. It also differs in composition, containing, according to Klaproth, Silica 29·5, Alumina 63·75, and Oxyd of Iron 6·75. No distinction has been noticed, however, in their forms.

OBS. This species was distinguished by Werner, and named from the Pini gallery in the Schneeberg mines, where it was first discovered. Prof. Shepard has united it with Mica, as a decomposed variety of this species. Its usually difficult cleavage seems, however, to be inconsistent with the supposition that it could arise from the alteration of so fissile a mineral as mica. Still there is much doubt connected with its specific nature.

Gieseckite appears to be but a variety of Pinite. It occurs in hexagonal prisms of a gray, green, or brown color; imperceptible cleavage, resinous lustre, and white streak. According to Stromeyer, it contains Silica 46·07, Alumina 33·82, Magnesia 1·20, Oxyd of Iron 3·35, Oxyd of Manganese 1·15, Potash 6·20, Water 4·88=96.67.

It occurs imbedded in decomposed feldspar-porphyry, at the Puy-de-Dome, in Auvergne; in granite, at Schneeberg, in Saxony; at Linsenz, in the Tyrol; and in primitive rocks in Cornwall and Aberdeenshire. Gieseckite was brought from Akulliarasiarsuk, in the district of Julianshope, in Greenland, by the late Sir Charles Giesecké, where it occurs imbedded in compact feldspar or quartz.

At Lancaster, Mass., this species occurs imbedded in quartz, associated with Andalusite; also at Haddam, Conn., with chrysoberyl, garnet, turmaline, &c.

FAHLUNITE. Stylus acrotomus.

Triclasite, *H.* Tricklasite, *P.* Fahlunite, *Hisinger.*

290. Occurs in six sided prisms. *Cleavage* perpendicular to the axis, or parallel to the base of the prism.

H.=3. G.=2·6—2·7. *Lustre* resinous or vitreous. *Streak* grayish-white. *Color* green, passing into dark-brown and black. Opaque.

It contains, according to Hisinger and Wachtmeister,

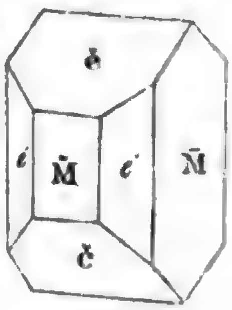
Silica	46·79	44·60
Alumina	29·73	30·10
Magnesia	2·97	6·75
Protoxyd of Iron	5·01	3·86
Oxyd of Manganese	0·43	2·24
Water	13·50=101·43, H.	9·35=96·90, W.

Before the blowpipe it becomes gray, and melts on its thinnest edges. It dissolves slowly with borax, yielding a glass slightly colored with iron.

Obs. It occurs in the mine of Eric Matts, near Fahlun, in Sweden, where it is found both massive and crystallized, imbedded in chlorite slate, and associated with copper pyrites, galena, and dichroite. The crystals, from their highly perfect cleavage, almost invariably break in parallel position with the slate, and thus present only sections of their form.

PICROSMINE. Nematus rectangulus.

Dihydrous Bisilicate of Magnesia, *Thomson.*



291. *Primary form:* a right rectangular prism, as deduced from cleavage. *Secondary form:* M̆ : é=153° 26′, é : é=126° 52′, M̆ : ĕ=121° 6′, ĕ : ĕ (over M̆) =62° 11′. *Cleavage* parallel to M̄ perfect, to M̆ less so. Occurs also imperfectly crystalline, and composed of fine columnar or granular particles.

H.=2·5—3. G.=2·596—2·66. *Lustre* of M̄ pearly; of other planes, inclining to vitreous. *Streak* white and dull. *Color* generally greenish-white, sometimes dark green. Subtranslucent—opaque. *Fracture* uneven, scarcely perceptible; of imperfectly crystalline varieties, splintery.

According to Magnus, (Poggendorf's Annalen, vi. 53,) it contains

Silica	54·88
Magnesia	33·35
Alumina	0·79
Peroxyd of Iron	1·39
Protoxyd of Manganese	0·42
Water	7·30=98·13.

It is infusible *per se;* but gives out water, becomes first black, then white and opaque, and acquires a hardness equal to 5. It is soluble in salt of phosphorus, with the exception of a skeleton of silica. When heated with nitrate of cobalt, it assumes a pale red color.

Obs. Picrosmine has been found only at the iron mine of Engelsburg, near Presnitz, in Bohemia, where it is associated with magnetic iron ore. It resembles common asbestus in external appearance, but was distinguished from that mineral by Haidinger, who named it Picrosmine, from πικρὸς, *bitter*, and ὀσμὴ, *odor*, in allusion to the bitter and argillaceous odor of the moistened mineral.

OSMELITE. Nematus scopiformis.

292. In thin prismatic concretions, scopiformly or stellularly arranged. *Cleavage* in one direction.

H.=4—5. G.=2·79—2·83. *Lustre* between pearly and vitreous—of low intensity. *Color* grayish-white, inclining to smoke-gray; on exposure, becomes dark hair-brown. Translucent. *Feel* greasy. *Odor*, when breathed upon, argillaceous. In the mouth it feels as if about to dissolve, although no change takes place.

Obs. It occurs on calcareous spar, mixed with datholite in trachyte, at Niederkirchen, near Wolfstein, on the Rhine. It was first described by Breithaupt. Its name is derived from ὀσμὴ, *odor*.

NEMALITE. Nematus gracilis.

Nuttall, Silliman's Jour. IV. 19. Amianthoid Magnesite. Silicious Hydrate of Magnesia, *Thomson*, Roy. Soc. Trans. Ed. XI. 468

293. Fibrous; fibres slender, elastic, sometimes curved, easily separable.

H.=2. G.=2·353, Thomson; 2·44, Nuttall. *Lustre* silky, or pearly. Some decomposed varieties have an earthy appearance. *Streak* white. *Color* grayish or bluish-white, sometimes slightly yellowish.

It is composed, according to Thomson, of

Magnesia	51·721
Silica	12·568
Peroxyd of Iron	5·874
Water	29·666=99·829.

In the flame of a lamp the fibres become opaque and rigid, and assume a light brown tinge. In this state the mineral is easily reducible to a powder. When rubbed with a piece of iron, the mineral phosphoresces with a yellowish light.

Obs. Nemalite forms veins in the serpentine rocks at Hoboken, in New Jersey. The name is derived from νημα, *a thread*, in allusion to its fibrous structure.

NATIVE MAGNESIA. Margaritus magnesicus.

Native Hydrate of Magnesia, Bruce's Min. Journ. I. 26. Native Magnesia, *Cleav.* Magnésie Hydraté, *H.*

294. *Primary form:* tetraxonal. *Secondary form:* (primary ?) a six sided prism. This form is of rare occurrence. Native mag-

nesia generally presents large foliated plates, easily separable. The planes of separation, or of cleavage, are parallel to the base of the hexagonal prism.

H.=1·5. G.=2·35, Haidinger. *Lustre* pearly. *Streak* white. *Color* white, inclining to gray, blue, or green. Translucent—subtranslucent. Sectile. Thin laminæ flexible.

It consists of

	Bruce.	Fyfe.	Vauquelin.	Stromeyer.		Thomson.
Magnesia	70	69·75	64·0	66·67	68·345	67·98
Water	30	30·25	29·0	30·30	29·902	30·96
Protox. Mang.	—	——	——	1·57	0·637	1·57
Protox. Iron	—	——	2·5	1·18	0·116	
Lime	—	——	——	0·19	——	——
Silica	—	——	2·0	——	——	——
	100	100·00	97·5	99·91	99·030	100·51

The first of the two analyses by Stromeyer, and that by Thomson, were of specimens from Swinaness. The others are analyses of Hoboken specimens.

Before the blowpipe it becomes opaque, loses weight, and is rendered friable, but does not fuse. It is entirely soluble in the acids without effervescence.

Obs. It occurs in considerable veins traversing serpentine, at Swinaness, in Unst, one of the Shetland isles; also in the same rock at Hoboken, N. J., opposite the city of New York, in veins which are sometimes an inch in width. This mineral was first discovered and described by the late Dr. Bruce, of New York.

TALC. MARGARITUS SAPONACEUS.

Prismatic Talc-Mica, *M.* Green Earth. Chlorite. Steatite. Vermiculite.

295. *Primary form:* a right rhombic prism; M : M=120°. *Secondary form:* it occurs in rectangular prisms and hexagonal plates. *Cleavage* perfect parallel with P. *Imperfect crystallizations:* globular and stellated groups; also massive; structure granular, often impalpable. Occasionally the particles are strongly coherent, and the mineral has a slaty structure.

H.=1—1·5. G.=2·697—2·713. *Lustre* pearly. Some massive varieties but slightly pearly, or nearly earthy. *Streak* usually white; of some dark-green varieties, a little lighter than the color. *Color* apple-green, passing into white, sometimes silvery-white; also inclining to greenish-gray, and dark-green. Sometimes the laminæ are bright green, viewed perpendicular to the cleavage surface, and of a brown tinge, and less translucent at right angles with this direction. Subtransparent—subtranslucent. *Fracture* of highly crystalline varieties not observable. Sectile in a high degree. Thin laminæ easily flexible, but not elastic. *Feel* greasy.

Several varieties of this mineral are distinguished by different names:

Green Earth includes the bluish or dark-green masses, imbedded in or coating the cavities of amygdaloid: it is the *Talc Zographique* of Haüy. Chlorite, (χλοϱος, *green*,) is applied to the dark-green or brownish varieties; if lamellar in its structure, it is termed *Foliated Chlorite*. When the massive variety is slaty, it is named *Chl Slate*. *Earthy Talc*, or *Nacrite*, consists of loose, slightly cohering particles.

rated Talc includes the light colored, and somewhat slaty varieties of common talc, with a nearly compact texture. *Steatite* is applied to the coarse gray and grayish-green massive varieties, having a very greasy feel. The name is derived from *στεαρ, fat*. *Vermiculite* is a variety of steatite, composed of minute foliated crystals. On heating the mineral, worm-like projections dart out on every side. These projections are composed of the separated foliæ of the crystals, and the result is probably owing to the vaporization of water. Hence its name, from vermiculus, *a little worm*. *Pot Stone*, or *Lapis Ollaris*, includes the coarse granular specimens, of a dark color.

The following are a few of the analyses of the different varieties of this species, according to Vauquelin and Thompson:

	Foliated Talc.	Foliated Talc.	Chlorite.	Nacrite.	Green Earth.
Silica	62·0	62·588	26·0	50·0	52·0
Magnesia	27·0	30·528	8·0	——	6·0
Oxyd of Iron	3·5	3·848	43·0	5·0	23·0
Alumina	1·5	——	18·5	26·0	7·0
Water	6·0	3·400	2·0	——	4·0
Potash	——	——	2·0	17·5	7·5
Lime	——	——	——	1·5	——
	100·0, V.	100·364, T.	99·5, V.	100·0, V.	99·5, V.

	Talc Slate.	Steatite.	Steatite.	Vermiculite.
Silica	57·560	42·320	43·884	49·080
Magnesia	27·216	25·680	24·144	16·964
Oxyd of Iron	4·716	9·384	9·872	16·120
Alumina	1·720	4·680	——	7·280
Water	1·600	1·083	——	10·276
Lime	7·944	16·960	21·228	——
	100·756, T.	100·107, T.	99·128, T.	99·720, T.

Before the blowpipe, some varieties lose their color, and fuse with difficulty; others, (the green earth in particular,) change into a blackish scoria, and are infusible, owing probably to the absence of potash and magnesia in their constitution.

Obs. This species is very generally diffused in primitive countries, and in some of its varieties, especially common talc, potstone, chlorite slate, and steatite, forms extensive beds in primitive regions, which are the repositories of several mineral species, among which are rhomb spar, dolomite, (var. bitter spar,) magnetic iron, apatite, and hornblende. Green earth occurs only in amygdaloidal rocks. Nacrite has been observed in veins of lead.

Apple-green talc occurs in large foliated masses, in the island of Unst, one of the Shetland Isles; also in the Gruner mountain, in Saltzburg; and in the Vallais. Other foreign localities are, of *green earth*, the Faroe Islands, Iceland, and the Tyrol; of *potstone*, the Valais and Grisons, and Wald, in Styria; of *nacrite*, St. Gothard and Monte Baldo, near Verona. The *soapstone*, which forms a vein in serpentine, at Lizard Point, Cornwall, when first extracted, may be kneaded like dough, but on exposure loses part of its moisture, and becomes subtranslucent. The above analyses of steatite by Thomson, are of specimens from this locality. Singular pseudomorphs of steatite, imitative of quartz crystal, and also of calc spar, occur at Göpfersgrüm, in the principality of Bayreuth, which were at first supposed to be actual crystals of steatite. Their pseudomorphous nature is, however, at the present time, very generally admitted.

Extensive beds of steatite occur in various parts of the New England states, also in New Jersey, Pennsylvania, &c. A bed at Smithfield, R. I., affords a delicate green columnar variety of talc, and a primitive limestone in the same region, a white granular variety. At Bridgewater, Vt., a handsome green talc occurs, intermingled with a transparent massive dolomite. Chlorite is of very frequent occurrence, and the chlorite slate formation is traceable from Vermont to Georgia.

Slabs of steatite are extensively employed as fire stones in furnaces and stoves, for which purpose it is well adapted, on account of its extreme infusibility, and its slow conduction of heat. Green earth is employed as a green color for painting houses, and when burnt, it forms a reddish-brown paint, which is applied to the same purpose. Venetian talc is used for removing oil-stains from woollen cloth.

ORDER II. CHALICINEA.

MARGARITE. Mica margarina.

Rhombohedral Pearl-Mica, *M.* Periglimmer, *L.*

296. *Primary form:* a hexagonal prism. *Cleavage* highly perfect parallel with the base of the prism; in traces parallel to its sides. It usually occurs in thin crystalline laminæ, irregularly intersecting each other.

H.=3·5—4·5. G.=3·032. *Lustre* pearly on P, vitreous on the other faces. *Streak* white. *Color* pale pearly-gray, passing into reddish-white, and yellowish-white. Translucent—subtranslucent. Rather brittle.

It contains, according to Du Menil,

Silica	37·00
Alumina	40·50
Oxyd of Iron	4·50
Lime	8·96
Soda	1·24
Water	1·00
Loss	6·80=100.

Obs. Margarite occurs at Sterzing, in the Tyrol, in primitive rocks, mixed with and engaged in foliated chlorite.

BLACK MICA. Mica hexagona.

Rhomboidal Talc-Mica, *M.* Mica Glimmer *of the Germans.*

297. *Primary form:* a rhombohedron. It occurs usually in six sided prisms. *Cleavage* highly eminent at right angles with the vertical axis. It is also common in foliated masses.

H.=2—2·5 G.=2·8—3. *Lustre* pearly; often submetallic on the terminal faces of the prism: splendent—shining. *Streak* gray, or white. *Color* commonly dark-green, or brown; often appearing nearly black, in thick masses. Transparent—opaque. Sectile. Thin laminæ are flexible, and very elastic.

It contains, according to Klaproth and H. Rose,

	Black, from Siberia.	Siberia.	
Silica	42·5	42·50	40·00
Alumina	11·5	16·05	12·67
Magnesia	9·0	25·97	15·70
Potash	10·0	7·55	5·61
Peroxyd of Iron	22·0	4·93	19·03
Oxyd of Mang.	2·0	——	0·63
Fluoric Acid	——=97, K.	7·55=104·55, R.	2·10=95·74, R.

Before the blowpipe, it becomes white and opaque; sometimes it fuses into a scoria.

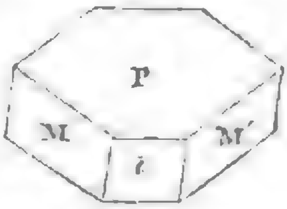
Obs. This species was long confounded with the following. Its distinctive characters were first discovered by an examination with polarized light, in which it exhibits but one axis of double refraction, or one system of rings, a fact inconsistent with the primary form of common mica. It also differs from this species in its composition, as it contains magnesia, which is not a constituent of the following species.

The most remarkable varieties of this species are the dark-colored micas from Siberia; and the deep brown and perfect hexagonal prisms, of gem-like brilliancy and transparency, which occupy the cavities of the ejected lavas of Vesuvius.

The localities of this species of mica in the United States, have not been distinguished from those of common mica.

COMMON MICA. Mica obliqua.

Hemi-prismatic Talc-Mica, *M.* Glimmer *of the Germans.* Lepidolite.



298. *Primary form:* an oblique rhombic prism; M : M= about 120°, P : M=98° 40′. *Secondary form:* the primary with the acute lateral edges truncated. M : ĕ=120°, M : M=60°. *Cleavage* eminent parallel to P. *Compound crystals: of the first kind*, in which composition has taken place parallel to M; frequently, composition takes places parallel to two or more lateral planes, producing compound crystals of several individuals having a stellated appearance. *Imperfect crystallizations:* occasionally present rough globular forms, composed of lamellar particles. Massive varieties usually have a lamellar composition, and are often composed of small aggregated scales.

H.=2—2·5. G.=2·832—3. *Lustre* more or less pearly. *Streak* white or gray. *Color* white, gray, pale-green, and violet-yellow, sometimes brown and dark olive-green. Transparent—translucent. Thin laminæ flexible and elastic, very tough. Sectile.

The analyses of this mineral give very different results. The following are a few of them, by Gmelin, H. Rose, and Turner: the two last are of specimens of violet colored mica.

	From Zinnwald.	From Broddbo.	From Kimito.
Silica	46·23	46·10	46·358
Alumina	14·14	31·16	36·800
Potash	4·90	8·34	9·220
Ox. of Iron	17·97	8·65	4·533
Ox. of Mang.	4·57	1·40	0·020
Fluoric Acid	8·73	1·12	0·760
Water		0·87	1·040
Lithia	4·21=95·75, G.	——=97·64, R.	——=98·731, R.

	Utön.		
Silica	47·50	50·35	52·254
Alumina	37·20	28·30	28·345
Potash	9·60	9·04	6·903
Ox. of Iron	3·20	—	—
Ox. of Mang.	0·90	1·23	3·663
Fluoric Acid	0·56	5·20	5·069
Water	1·39		—
Lithia	—=100·35, R.	5·49=99·61, T.	4·792=101·026, R.

The violet varieties usually contain several per cent. of lithia, which is mostly wanting in those of other colors.

Common mica generally does not fuse before the blowpipe, but only loses its transparency and becomes white; those specimens, however, which contain lithia, melt readily, and at the moment of fusion, tinge the flame of a delicate red. A violet variety occurring in small scales, has been distinguished by the name lepidolite.

Obs. Mica is one of the constituents of granite, and its associate rocks, gneiss and mica slate. It also occurs in more recent aggregate rocks; also in imbedded crystals in granular limestone, wacke, and basalt. Coarse lamellar aggregations often form the matrix of crystals of topaz, turmaline, and other mineral species.

Siberia affords laminæ of mica, sometimes exceeding a yard in diameter.

Fine crystallizations of mica occur in granite, at Acworth, N. H. Goshen and Chesterfield, Mass., afford rose colored crystals in granite, associated with turmaline. An emerald-green variety occurs at Brunswick, Me., and the lepidolite variety at Paris, of the same state, where it is intersected by crystals of red turmaline: the same variety is also found at Middletown, Conn. Handsome crystals, of a reddish-brown color, occur at Greenfield, near Saratoga, N. Y., in the granite vein that contains chrysoberyl, turmaline, and crystals of feldspar: these crystals when viewed across the axis, have a rich oil-green color. Near the iron mines of Munroe, at Greenwood, N. Y., highly perfect crystals of a large size and a dark greenish-black color, are contained in a vein about a foot in width. The form is an obtuse oblique rhombic prism. Perfect crystals of a small size, occur in the limestone of Orange Co. N. Y., associated with spinel and Brucite. A yellow variety, somewhat copper colored, is found in six sided tables of large size at Henderson, Jefferson Co., N. Y. A dark-brown variety occurs near Moriah, upon Lake Champlain, in plates of moderate size. Black crystals, presenting a hexagonal form, occur near Germantown, Penn., on the Schuylkill; and on the Wilmington road near the woodlands. A green variety is found at Chestnut hill, near the Wichichon, Penn.

This species will probably be divided, when the distinguishing characteristics of its several varieties have been more studied. The oblique rhombic prism, which is their primary, is, in some, oblique from an obtuse edge, in others, from an acute. Further examinations are necessary, previous to making the division which is therefore required.

When quite thin, the laminæ of mica are often transparent, and have been used in Siberia for windows. It is hence sometimes called Muscovy glass. It however soon loses its transparency on exposure, and is but a poor substitute for the valuable product of art in general use. It is also used on board the Russian naval vessels, as it is less liable to fracture with the concussion produced by the discharge of heavy artillery.

SCHILLER SPAR. Phyllinius Schilleri.

Diatomous Schiller Spar, *M.* Hydrous Bisilicate of Magnesia, *Thom.* Otrelite. Karstin. Schillerstein, *W.* Talkartiger Diallag, *Haus.* Spath-Chatoyant, Diallage Métalloide, (in part,) *H.*

299. *Primary form:* an oblique rhomboidal prism; M : T= between 135° and 145°. *Cleavage* in two directions, in one of which it is highly perfect and easily effected; in the other, it appears only in traces. It usually occurs in broad separable laminæ, disseminated in serpentine.

H.=3·5—4. G.=2—2·652, Köhler. *Lustre* metallic-pearly on cleavage faces, indistinctly vitreous on the other faces. *Streak* grayish-white, inclining a little to yellow. *Color* olive- and blackish-green, inclining to pinchbeck-brown upon the face of perfect cleavage. Subtranslucent. *Fracture* uneven, splintery. Sectile.

Its composition, as determined by Drapier, (Jour. de Ph. lxii. 48,) and Köhler, (Poggend. Annalen, ii. 192,) is as follows,

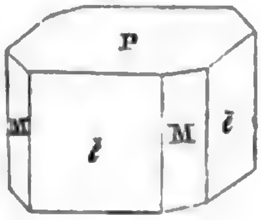
Silica	41	43·900
Magnesia,	29	25·856
Oxyd of Iron and Chromium	14	13·021
Water	10	12·426
Alumina	3	1·280
Lime	1	2·642
Protox. Manganese	—=98, Drapier.	0·535=99·66, Köhler.

In the flame of the blowpipe, supported by platinum forceps, it gives off water and becomes of a pinchbeck-brown color; the lustre is rendered still more metallic; in this manner thin pieces become attractable by the magnet. Fusion of the thinnest edges only can be effected by the blowpipe alone. With borax, it fuses with difficulty; the bead on cooling has a slight emerald-green tinge in consequence of the presence of chromium. The same phenomena are exhibited with biphosphate of soda, and a skeleton of silica is left. With carbonate of soda, it does not fuse, but exhibits on platinum foil the presence of manganese.

Obs. Schiller spar occurs at Baste, in the Forest of Harzeburg, in the Hartz, where it occurs mixed with massive serpentine in greenstone At Blandford, Mass., a blackish-green variety is met with, associated with serpentine and marmolite; also near Westfield, Mass.

BRONZITE. Phyllinius æreus.

Hemi-prismatic Schiller-Spar, *M.* Schiller Spar, (in part,) Blättriger Anthophyllite, *W.* Diallage Fibro-Laminaire Métalloide, *H.*



300. *Primary form:* an oblique rhombic prism; M : M=94° or 86°. *Secondary form:* P : ĕ=108°, M : ĕ=133°, M : ē=137°. *Cleavage* very perfect parallel with P; indistinct parallel with M and the diagonals of the prism. It is commonly found imbedded in its matrix in crystalline masses, which cleave with facility into thin laminæ.

H.=4—5. G.=3·251, a brown variety from Bayreuth. *Lustre* metallic-pearly, often resembling bronze. *Streak* grayish, corresponding to the color. *Color* several shades of dark green; liver and pinchbeck-brown; also ash-gray. Translucent—subtranslucent. Easily frangible.

It contains

Silica	60·0	56·813
Magnesia	27·5	29·677
Protoxyd of Iron	10·5	8·464
Protox. of Manganese	—	0·616
Alumina	—	2·068
Water	0·05	0·217
Lime	—=98·5, Klaproth.	2·195=100·050, Köhler.

It assumes a lighter color when heated, and gives off water; but is infusible alone before the blowpipe.

Obs. Bronzite occurs imbedded in serpentine and greenstone rocks. In serpentine, on Monte Bracco, near Sestri, on the coast road from Genoa to Nice, this species occurs in extremely large individuals of a beautiful pearly-gray color: also at Monte Ferato, near Florence, and in many other places along the Appennines, bronzite is quite abundant. It is met with also at Leprese, in the Venetian territory, and near Hof and Beyreuth; also in the Lizard district of Cornwall, where it is of a peculiarly dark-brown color.

SEYBERTITE. Phyllinius Seybertianus.

Seybertite, *Clemson*, Silliman's Am. Jour. XXIV. 171. Holmesite, *Thomson*.

301. Occurs in foliated masses.

H.=4—5. G.=3·098. *Lustre* metallic and metallic-pearly. *Streak* white, grayish-white. *Color* reddish-brown. Subtranslucent.

It contains, according to T. G. Clemson and Dr. T. Thomson,

Silica	17·0		19·35
Alumina	37·6		44·75
Magnesia	24·3		9·05
Lime	10·7		11·45
Protoxyd of Iron	05·0	Perox.	4·80
Oxyd of Manganese	——		1·35
Zirconia	——		2·05
Water	3·6		4·55
Fluoric Acid	——=98·2, C.		0·90=98·25, T.

It is infusible, *per se*, before the blowpipe. With carbonate of soda, on borax, a transparent pearl is obtained. In the state of a powder, it is acted upon by the nitric, muriatic, and sulphuric acids.

Obs. It occurs at Amity, Orange Co., N. Y., in limestone beds connected with serpentine, and associated with hornblende, pyroxene, and plumbago. This species has been supposed to be a variety of bronzite, but the above analyses, though disagreeing, prove it to be a distinct species. It was named by Clemson, in honor of Mr. Henry Seybert. More lately, Dr. Thomson has analyzed it and named it Holmesite. (Records of General Science, iii.)

HYPERSTHENE. Phyllinius metallinus.

Prismatoidal Schiller-spar, *M.* Labrador Schiller-spar, *J.* Labradorische Hornblende, Paulit, *W.* Diallage Métalloide, *H.*

302. *Primary form:* an oblique rhombic prism: M : M= about 93° 30′, and 86° 30′. *Cleavage* parallel to M and the shorter diagonal; very indistinct parallel to the base. The crystals are almost invariably imperfect at their extremities. A secondary form, consisting of the primary with beveled acute lateral edges, is met with at Warwick, N. Y. Occurs also massive.

H.=6. G.=3·389. *Lustre* bright metallic-pearly on the cleavage faces parallel to the diagonal: in other directions vitreous; sometimes silvery. *Streak* greenish-gray. *Color* grayish or greenish-black; also copper-red. Faintly subtranslucent—opaque. *Fracture* uneven. Brittle.

According to Klaproth, it contains

Silica	54·25
Magnesia	14·00
Alumina	2·25
Lime	1·50
Oxyd of Iron	24·50
Water	1·00
Manganese	trace.=97·5.

Before the blowpipe, *per se*, it is unaltered. On charcoal, it fuses into a greenish-gray opaque globule. With borax, a green glass is readily formed.

Obs. This mineral was first brought from the island of St. Paul, on the coast of Labrador, where it occurs in rolled masses. At Cuchullin, Isle of Skye, a range of mountains is composed almost entirely of hypersthene and feldspar. It is also found at Baffin's Bay.

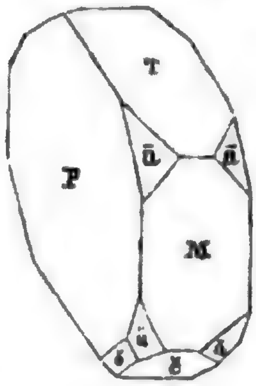
At Warwick, N. Y., it occurs with Brucite, in the limestone formation with which serpentine is associated. Its crystals are sometimes several inches long and half an inch in diameter; in general, however, they are quite minute.

Hypersthene is derived from υπερ, *above*, and σθενος, *strength*, in allusion to its greater hardness and lustre than hornblende, with which it was confounded.

HEULANDITE. VULCANUS RHOMBOIDEUS.

Hemi-prismatic Kouphone-Spar, *M.* Hemi-prismatic Zeolite, Foliated Zeolite, *J.* and *W.* Stilbite anamorphique, *Haüy*. Stilbite, (in part.) Blättriger Stilbit, *Haus*. Blätterzeolit, *W.*

303. *Primary form:* a right rhomboidal prism; M : T=130° 30′. *Secondary form:* the annexed figure; M : ā=146°, T : ā=148°. P : ā=111° 56′. M : ĕ=114° 20′. P : ă=133° 35′. *Cleavage* parallel with P highly perfect. Its imperfect forms present sometimes globular forms in vesicular cavities; at others, they occur granularly massive.



H.=3·5—4. G.=2·2, Haidinger; 2·195, Thomson, a crystal from the Faroe Islands. *Lustre* of P perfect—pearly; of other faces, vitreous. *Streak* white. *Color* various shades of white; passing into red, gray, and brown. Transparent—subtranslucent. *Fracture* subconchoidal, uneven. Brittle.

It contains, according to Walmstedt, (Edinb. Journ. vii. 11,) and Thomson, (Min. i. 347,)

	From Campsie.	From Faroe.
Silica	59·95	59·145
Alumina	16·87	17·920
Lime	7·19	7·652
Water	15·10=99·11, W.	15·400=100·117, T.

It fuses in the blowpipe flame, with a slight intumescence, and is rendered phosphorescent. It does not gelatinize with acids.

Obs. Heulandite occurs principally in amygdaloidal rocks. It has been found also in metalliferous veins.

The finest specimens of this species come from Iceland and the Faroe Islands, and also the Vendayah Mts., in Hindostan. The red varieties occur at Campsie, in Sterlingshire, with stilbite of the same color. At Arendal it is met with of a brown tint. It also occurs in the Kilpatrick hills, near Glasgow.

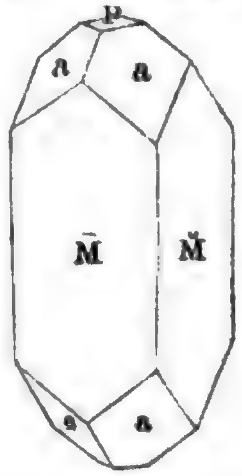
At Peter's Point, Nova Scotia, it occurs in trap, presenting white and flesh-red colors, and associated with Laumonite, apophyllite, Thomsonite, &c.; also at Cape

Blomidon, and other places in the same region, in crystals an inch and a half in length.

This species was named by Mr. Brooke from Mr. Heuland, of London, to whom the science of Mineralogy is much indebted. It may be distinguished from stilbite by its crystalline form, and its more perfectly pearly lustre.

STILBITE. VULCANUS FASCICULARIS.

Prismatoidal Kouphone Spar, *M.* Radiated Zeolite, *J.* Foliated Zeolite, Strahlzeolith, *W.* Blättrich-strahliger Stilbite, *Haus.*



304. *Primary form:* a right rectangular prism. *Secondary form:* the annexed figure; a : a=119° 15′, M̄ : a=120° 30′. Frequently the lateral edges are replaced, and M̄ : *e*=136° 30′. *Cleavage* parallel to M̆ perfect, to M̄ less so. *Compound crystals* of a cruciform character are rarely met with. The crystals are frequently aggregated in the form of a sheath. Globular, divergent, and radiated forms, also occur, composed of columnar or thin lamellar particles.

H.=3·5—4. G.=2·133—2·143, Thomson; 2·161, Haidinger. *Lustre* of M̆, both as faces of crystallization and cleavage, pearly; of other faces vitreous. *Streak* white. *Color* white; occasionally yellow, brown, or red. Subtransparent—translucent. *Fracture* uneven. Brittle.

It contains, according to Dumenil, (Schweigger's Jahrbuch, vi. 163,) and Thomson, (Min. i. 345,)

Silica	52·25	52·500	54·805
Alumina	18·75	17·318	18·205
Lime	7·36	11·520	9·830
Soda	2·39	—	—
Water	18·75=99·50, D.	18·450=99·788, T.	19·000=101·840, T.

Before the blowpipe, it yields a colorless glass. It does not gelatinize with acids, except after a long exposure to, and frequent boiling in nitric acid.

Obs. Stilbite occurs mostly in cavities in amygdaloidal trap. It is also found in some metalliferous veins, and on granite and gneiss.

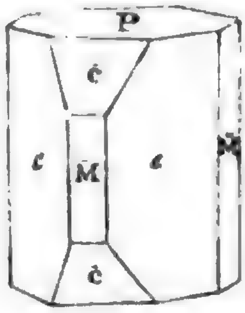
Stilbite is met with in great abundance on the Faroe Islands, in Iceland, and the Isle of Skye, in trap. At Andreasberg, in the Hartz, and Kongsberg and Arundel, in Norway, it occurs in veins and beds of iron ore. Judore, in the Vendayah Mts. in Hindostan, affords large translucent crystals, having a reddish tinge. Fine crystals, of a brick-red color, occur in porphyritic amygdaloid, near Kilpatrick, in Dumbartonshire. A brown variety occurs on granite, at the copper mines of Gustafsberg, near Fahlun, in Sweden. At Patridge Island, Nova Scotia, this species forms a perpendicular vein from three to four inches thick, and from thirty to fifty feet long, intersecting amygdaloid. Its colors are white and flesh-red. It is accompanied with wine-colored carbonate of lime. The specimens there obtained are extremely beautiful.

Stilbite is easily distinguished from the preceding species, by its property of not gelatinizing with acids; and from gypsum, which it sometimes resembles, by its superior hardness.

THOMSONITE. Vulcanus Thomsonianus.

Orthotomous Kouphone-Spar, *M.* Mesotype (in part) *of Haüy.* Needle Zeolite (in part) *of Werner.*

305. *Primary form:* a right rectangular prism. *Secondary form:* the annexed figure; $\bar{M}$: e=135° 20′, $\breve{M}$: e= 134° 40′, P : $\bar{e}$=125°. *Cleavage* parallel to $\bar{M}$ and $\breve{M}$ easily obtained. *Imperfect crystallizations:* columnar radiated structure; also amorphous.



H.=4·75. G.=2·29—2·3697. *Lustre* vitreous, inclining to pearly. *Streak* white. *Color* snow-white; impure varieties brown. Transparent—translucent. *Fracture* uneven. Brittle.

It contains, according to Thomson, (Min. i. 315,) and Berzelius, (Edin. Journ. iii. 9,)

	From Lochwinnoch.	
Silica	37·560	38·30
Alumina	31·960	30·20
Lime	15·096	13·54
Magnesia	1·080	——
Protox. Iron	0·720	——
Soda	——	4·53
Water	13·200=99·616, T.	13·10=99·67, B.

Before the blowpipe, it swells up like borax, and becomes opaque and snow-white. At a high heat, the edges merely are rounded.

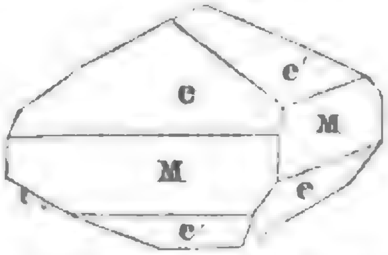
Obs. Thomsonite occurs in the neighborhood of Glasgow, at Lochwinnoch, and near Kilpatrick, imbedded in an amygdaloidal rock. It was named by Mr. Brooke, who first distinguished the species, in honor of Dr. Thomson, of Glasgow.

It has also been found in long slender prisms, of a grayish-white color, at Peter's Point, Nova Scotia, where it occurs in trap, and is associated with Laumonite, apophyllite, mesotype, and other trap minerals.

EDINGTONITE. Vulcanus hemiquadratus.

Hemi-pyramidal Feldspar, *Haid.* Brewster's Journ. iii. 376.

306. *Primary form:* a right square prism. *Secondary form:* a hemihedral crystal, the upper and lower basal edges of the same lateral face being differently modified. M : e′=154° 34′, e′ : e′ (over the summit) =129° 8′. M : e=136° 20½′. e : e (over the summit) =92° 41′. *Cleavage* parallel to M perfect.



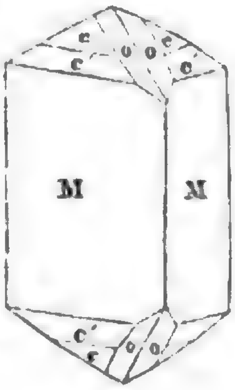
H.=4—4·5. G.=2·7—2·75. *Lustre* vitreous. *Streak* white. *Color* grayish-white. Translucent. Brittle.

It contains, according to an imperfect analysis by Dr. Turner, Silica 35·09, Alumina 27·69, Lime 12·68, Water 13·32, and, as Dr. T. supposes, 10 or 11 per cent. of some alkali; the quantity of the mineral subjected to analysis was so small, that he was unable to determine its nature more particularly. At a high heat, before the blowpipe, it fuses into a colorless mass, having first given off water, and become white and opaque.

Obs. Edingtonite was first observed by Mr. Haidinger, in small but distinct crystals, on a specimen of Thomsonite from Dumbartonshire, in the collection of Mr. Edington, of Glasgow. It is extremely rare.

NATROLITE. Vulcanus rhombicus.

Prismatic Kouphone-Spar, *M.* Prismatic Zeolite, or Mesotype, *J.* Mesotype, *P.*, *H.* Faserzeolith, Natrolith, *W.* Crocalite. Edelite. Hoganite, Feather Zeolite.



307. *Primary form:* a right rhombic prism; M : M=91° 10′, according to Gehlen and Fuchs, and also Mr. Brooke. *Secondary form:* M : e=116° 37′, e : e (adjacent planes)=126° 47′, e : e (over o)=143° 14,′ e : o=178° 45′, o : o=145° 44′, Brooke. Other secondaries exhibit only the terminal planes e, in connection with the lateral. The obtuse lateral edges are also frequently beveled or truncated; M : *e* (the truncating plane)=135° 35′. *Cleavage* parallel to M perfect. *Imperfect crystallizations:* globular, divergent, and stellated forms, composed of delicate acicular crystals, or narrow laminæ. It also occurs in dull friable masses, having an earthy fracture.

H.=4·5—5·5. G.=2·139—2·2303, Thomson. *Lustre* vitreous. *Streak* gray. *Color* white, inclining to yellow or gray; sometimes red. Transparent—translucent. *Fracture* uneven. Brittle.

The following are a few of its analyses; the first by Gehlen and Fuchs, (Schweig. Jour. xviii. 11,) the second and third by Thomson, (Min. i. 317.)

		From Auvergne.	From Antun.
Silica	48·0	48·04	47·560
Alumina	26·5	25·03	26·420
Protoxyd of Iron	——	——	0·580
Soda	16·2	16·76	14·932
Lime	——	——	1·400
Water	9·3=100.	9·65=99·48.	10·440=101·332.

Before the blowpipe it becomes opaque, gives off a phosphorescent light, and melts into a glassy globule. It dissolves in the acids, and forms a thick jelly; this will even take place after the mineral has been exposed to a red heat. It becomes electric by heat, and sometimes also phosphoresces.

Obs. Natrolite was originally included, together with several other species, under the general name of Zeolite. From these it was distinguished by Haüy, who denominated it *mesotype.* Since then it has been discovered, both by analysis and crystallographic considerations, that the species, mesotype, included two distinct minerals; one of which was identical with *natrolite*, a mammillary mineral, from Högan, so named by Klaproth, and the other was named *scolecite.* Still another species has been made on crystallographic examination, which retains the old name, *mesotype.*

Natrolite occurs in cavities in amygdaloidal and volcanic rocks, associated with analcime and chabazite.

Auvergne; the *graustein* of Aussig, in Bohemia; the trap rocks of Kilmalcolm, in Renfrewshire and Glenarm, in the county Antrim, are some of its foreign localities; also Duron, in the Fassa valley, where it is met with in radiating groups of a fine red color.

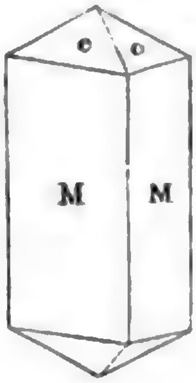
Natrolite is met with in the trap of Nova Scotia; also in the same rock at Cheshire, Conn. At Washington, Conn., it is stated to occur in seams, between hornblende and gneiss.

Natrolite is so called from natron, *soda;* alluding to the soda it contains.

The stellite of Dr. Thomson is closely allied to this species; it is, however, somewhat different in composition, and may be entitled to the rank of a species. It occurs in snow-white stellar aggregations on greenstone, near Kylsyth, on the banks of the Forth and Clyde canal. The cavities of crystals are about an inch in diameter, with their circumferences united and confused. Lustre silky, shining. Translucent. H.=3·25. G.=2·612. It contains, according to Thomson, Silica 48·465, Lime 30·96, Magnesia 5·58, Alumina 5·301, Protoxyd of Iron 3·534, Water 6·108=99·948. It fuses into a white enamel before the blowpipe.

MESOTYPE. VULCANUS PERITOMUS.

Peritomous Kouphone-Spar, *Haid.* Zeolith, *W.* Mesotype, (in part.)



308. *Primary form:* a right rhombic prism; M : M=91° 28′, Haidinger. *Secondary form:* the annexed figure. *Cleavage* parallel to M perfect. Occurs also fibrous, in stellated or divergent groups, and occasionally compact; also at times pulverulent.

H.=5—5·5. G.=2·2—2·3. *Lustre* vitreous. *Streak* white, or grayish-white. *Color* white, sometimes inclining to gray, or red. Transparent—translucent. *Fracture* of compact varieties splintery.

Its constituents are, according to Gehlen,

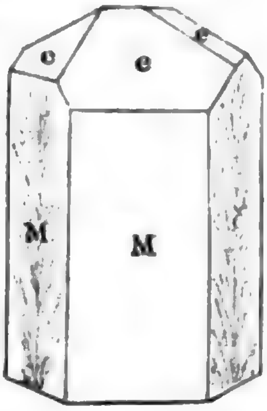
Silica	54·46
Alumina	19·70
Soda	15·09
Lime	1·61
Water	9·83=100·69.

Before the blowpipe the crystals become opaque without intumescing, and form a glassy globule. With borax, fusion is obtained with difficulty.

Obs. Mesotype occurs at the Faroe Islands, forming divergent groups in the vesicular cavities of amygdaloid; also in the trap rocks of the Giant's Causeway, in very delicate acicular crystallizations, and aggregated in radiating forms. It is met with in trap tufa, associated with analcime, at Montecchio Maggiore, in the Vicentine; and in the more ancient of the Vesuvian lavas, in small silky diverging tufts.

SCOLECITE. VULCANUS CRISPANS.

Harmophanous Kouphone-Spar, *Haid.* Mesolite. Needlestone. Mesotype, (in part.)



309. *Primary form:* a right rhombic prism; M : M=91° 25′. *Secondary form:* the primary with the acute lateral edges truncated; also with the terminal edges replaced so as to form a four sided pyramid at the extremity of the crystal. *Compound crystals:* similar to the annexed fig. The crystals are commonly slender, and occur interlacing one another, or in diverging groups. Scolecite is also found in radiating masses, and occasionally compact.

H.=5—5·5. G.=2·214—2·27. *Lustre* vitreous, inclining to pearly. *Streak* white. *Color* white. Transparent—translucent.

It contains, according to Fuchs and Gehlen, and Berzelius,

	Faroe.	Staffa.	Faroe.
Silica	46·49	46·75	46·80
Alumina	25·88	24·82	26·50
Lime	13·86	14·20	9·87
Water	13·62	13·64	12·30
Soda	0·48=100·23, F. & G.	0·39=99·08, F. & G.	5·40=100·87, B.

In the exterior flame of the blowpipe it becomes opaque, and then curls up like a worm, and finally melts into a very bulky and shining slag. In the interior flame this slag falls down, and is converted into a vesicular and slightly translucent bead. It becomes electric when heated.

It dissolves readily, and forms a thick gelatinous mass, with nitric and muriatic acids before, but not after ignition.

Obs. Scolecite differs from the preceding species in containing lime instead of soda. A variety, consisting of a mixture of scolecite and natrolite, has been separated from this species under the name of *mesolite.* In all its important characters, both the physical and those obtained by the action of acids, it resembles scolecite.

Scolecite occurs at Tiegerhottue, in the Berufiord, Iceland, where the crystals often exceed two inches in length, and are occasionally a quarter of an inch thick. It has also been met with in amygdaloid, at the Faroe Islands, Staffa; the Vendayah mountains, Hindostan; in Greenland; and at Pargas, Finland. It occurs also in veins in Kilpatrick hills.

Scolecite is derived from σκωληξ, *a worm*, in allusion to its action before the blowpipe.

CARPHOLITE. Vulcanus stramineus.

Karpholite, *J.*

310. Structure columnar, radiated and stellular, in tufts; particles rather incoherent.

H. about 5. G.=2·935, Breithaupt; 2·9365, Stromeyer. *Lustre* silky, glistening. *Color* pure straw-yellow; sometimes wax-yellow. Opaque. Very brittle.

The following is its composition, according to Stromeyer, (Untersuchungen, 410,) and Steinmann, (Schweig. Jour. xxv. 413,)

Silica	36·154	37·53
Alumina	28·669	26·48
Protox. Manganese	19·160	17·09
Protox. Iron	2·290	5·64
Lime	0·271	—
Fluoric Acid	1·470	—
Water	10·780=98·794, Strom.	11·36=98·10, Stein.

It intumesces before the blowpipe, whitens, and fuses slowly into a brown opaque mass. With borax it forms a transparent glass, which, in the outer flame, assumes an amethystine color; in the reducing flame it becomes green.

Obs. It occurs in minute divergent tufts, disposed on granite, along with fluor and quartz, in the tin mines of Schlaggenwald. It was named by Werner, in allusion to its color, from καρφος, *straw*.

DYSCLASITE. Vulcanus tenax.

Dysclasite, *Connell*. Okenite, *Kobell*.

311. Structure delicately fibrous; also imperfectly fibrous or composed of a congeries of minute crystals.

H.=4·5—5. G.=2·362 of dysclasite, Connell; 2·28 of Okenite, Kobell. *Lustre* inclining to pearly. *Color* white, with a shade of yellow or blue; often yellow by reflected light, and blue by transmitted; frequently with an opalescent tint. Subtransparent—subtranslucent. Very tough. Exhibits double refraction.

Its composition, according to Connell and Kobell, is as follows:

Silica	57·69	56·99	55·61
Lime	26·83	26·35	26·59
Water	14·71	16·65	17·00
Soda	0·44	——	——
Protoxyd of Manganese	0·22	——	——
Potash	0·33	——	} 0·53
Peroxyd of Iron	0·32	——	
Alumina	——=100·54, C.	——=99·99, K.	——=99·73, K.

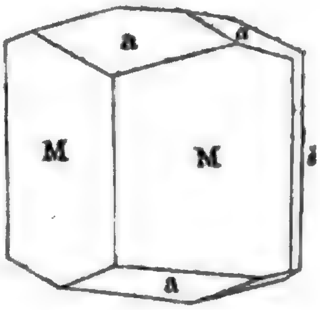
When heated in a glass tube, water is obtained. Before the blowpipe, *per se*, it becomes opaque and white, and fuses on the edges. It effervesces with carbonate of soda, and fuses into a subtransparent glass; with borax it forms a transparent colorless glass.

Pieces thrown into muriatic acid gradually become gelatinous. In a pulverized state, a jelly is readily formed.

Obs. The *dysclasite* of Connell was brought from the Faroe Islands by Count Varges Redemar, of Copenhagen. It was at first mistaken for mesotype. Okenite occurs, with other minerals of this family, in amygdaloid, in Greenland. Dysclasite is derived from δυς, *difficultly*, and κλαειν, *to break*.

EPISTILBITE. Vulcanus acutus.

Diplogenic Kouphone-Spar, *Haid*. *Rose*, in Brewster's Jour. IV. 283.



312. *Primary form:* a right rhombic prism; M : M=44° 50′, and 135° 10′. *Secondary form:* M : ĕ=112° 25′, *a* : ĕ=106° 10′, a : a=109° 46′, M : a=122° 9′. *Cleavage* parallel to the shorter diagonal perfect; indistinct in other directions. Face M mostly uneven. It presents occasionally twin crystals of *the first kind*. Occurs also granularly massive.

H.=4—4·5. G.=2·249—2·25. *Lustre* pearly upon the cleavage face; upon M vitreous. *Streak* and *Color* white. Transparent—subtranslucent. Fracture uneven.

It contains, according to Rose,

Silica	58·59	60·28
Alumina	17·52	17·36
Lime	7·56	8·32
Water	14·48	12·52
Soda	1·78=99·93.	——=98·48.

It froths in the blowpipe flame, and forms a vesicular enamel, but cannot be fused into a globule. Borax dissolves a great part of it, and forms a clear globule. It is also soluble in salt of phosphorus, with the exception of a skeleton of silica. It is soluble in concentrated muriatic acid, with the exception of a fine granular residue of silica.

Obs. Epistilbite is associated with scolecite at the Berufiord, in Iceland, and is also found at Poonah, in India.

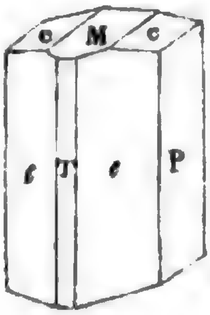
This species was separated from stilbite by Dr. G. Rose, of Berlin, from which it is perfectly distinct in its crystallization. It is also peculiar in exhibiting but one system of rings in polarized light, as has been determined by Dr. Brewster. The double refraction of Heulandite, is also much greater than that of the mineral just described.

BREWSTERITE. Vulcanus Breusterianus.

Brewsteritic Kouphone-Spar, *Haid.* Brewsterite, *Brooke*, Edin. Phil. Jour. VI. 112.

313. *Primary form :* a right rhomboidal prism; M : T=93° 40′. *Secondary form :* M : e=176°, e : e=172°. *Cleavage* highly perfect parallel to P.

H.=5—5·5. G.=2·12—2·432; the latter according to Thomson. *Lustre* of P pearly; of other faces vitreous. *Streak* white. *Color* white, inclining to yellow and gray. Transparent—translucent. *Fracture* uneven.



It contains, according to Dr. Thomson, (Min. i. 348,)

Silica	53·045
Alumina	16·540
Baryta	6·050
Strontia	9·005
Lime	0·800
Water	14·735=100·175.

Before the blowpipe it parts with its water and becomes opaque; it then froths and swells up, but fuses with difficulty. It leaves a silica skeleton when fused with biphosphate of soda.

Obs. Brewsterite was first observed at Strontian, in Argyleshire, where it occurs associated with calcareous spar. It has since been discovered in the Giants' Causeway, coating the cavities of amygdaloid; in the lead mines of St. Turpet, near Freiburg, in the Brisgau; in the department of the Isère, in France, and in the Pyrenees.

MESOLITE. Vulcanus flabelliformis.

Flabelliform Kouphone-Spar, *Haid.* Brewster's Journal, VII. 18.

314. *Primary form :* trimetric. Usually occurs in implanted globules, which have a flat columnar or lamellar structure, radiating from the centre. *Cleavage* perfect in one direction.

H.=3·5. G.=2·35—2·4. *Lustre* silky or pearly. *Streak* white. *Color* grayish white; sometimes yellow. Translucent. Laminæ slightly elastic.

It is composed, according to Hisinger and Berzelius, of

	Sweden.	Faroe.
Silica	42·17	42·60
Alumina	27·00	28·00
Lime	9·00	11·43
Soda	10·19	5·63
Water	11·79=100·15, H.	12·70=100·36, B.

Obs. Mesolite occurs, coating the vesicular cavities of amygdaloid and basalt, at Nalsoe, in the Faroe Islands, where it is associated with chabazite, apophyllite, stilbite, and others of the zeolite family. Also in Disco Island, Greenland, in aggregations which bear much resemblance to crystallized spermaceti.

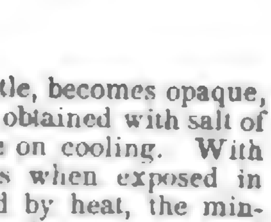
Mesolite is distinguished from mesotype by its perfect single cleavage and pearly lustre; from stilbite or Heulandite, by its superior specific gravity; and from apophyllite, by its crest or fan-like aggregations, which are never presented by that mineral. When associated with apophyllite or stilbite, it forms the lowest stratum, immediately adjoining the rock in which it is situated.

Dr. Thomson has described a mineral under the name of Harringtonite, whose composition is very similar to that of mesolite. It constituted a vein about 0·6 inch thick in an amygdaloid, in the north of Ireland. Its description is as follows: *Color* snow-white; texture compact and earthy; *lustre* like that of the almond; opaque; very tough. The following are the results of two analyses:

Silica	44·960	44·840
Alumina	26·848	28·484
Lime	11·008	10·684
Protoxyd of Iron	0·880	trace.
Soda	5·560	5·560
Water, with trace of muriatic acid	10·280=99·536,	10·280=99·848.

COMPTONITE. Vulcanus Comptonianus.

Comptonitic Kouphone-Spar, *Haid.* *Brewster*, in Ed. Phil. Journ. IV. 131, and VI. 119.



315. *Primary form:* a right rectangular prism. *Secondary form:* $\bar{M}$: e=135° 30′, $\breve{M}$: e=134° 30′, $\breve{M}$: $\breve{e}$=92° 13′, $\breve{e}$: $\breve{e}$=175° 35′. *Cleavage* parallel to $\breve{M}$ and $\bar{M}$, the first a little more distinct. It frequently occurs as a coating on other minerals of this family.

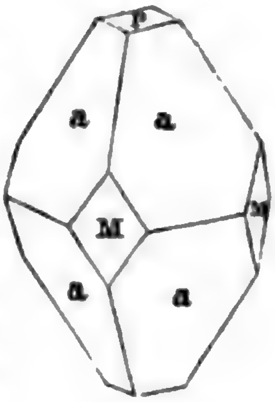
H.=5—5·5. G.=2·35—2·4. *Lustre* vitreous. *Streak* and *Color* white. Transparent—translucent. *Fracture* small conchoidal, uneven.

Before the blowpipe it parts with some water, intumesces a little, becomes opaque, and then fuses imperfectly into a vesicular glass. The globule, obtained with salt of phosphorus, contains a skeleton of silica, and becomes opaque on cooling. With borax, the globule is transparent and vesicular. It gelatinizes when exposed in powder to nitric, or muriatic acid. If it has been anhydrated by heat, the mineral is still dissolved by muriatic acid, but the silica separates in a powder, and does not gelatinize.

Comptonite was first found by Lord Compton, in the cavities of the vesicular lava of Vesuvius, associated with capillary mesotype, and other species of the genus Vulcanus. It has since been discovered in basalt, at the Pflaster Kaute, near Eisenach, in Hessia; also at Leitmeritz and Hauenstein, in Bohemia, forming a thin coating on the surface of mesotype, and occupying the cavities of *graustein*. At the Cyclopean Islands, Sicily, it occurs associated with analcime and Phillipsite.

APOPHYLLITE. Vulcanus quadratus.

Pyramidal Kouphone-Spar, *M.* Pyramidal Zeolite, *J.* Tesselite, *Brewster.* Ichthyophthalmite. Albin, *Wern.* Fischaugenstein, *Wern.* Mesotype Epointée, *H.*



316. *Primary form:* a right square prism. *Secondary form:* similar to fig. 51, Pl. I., also the annexed figure; a : a=104° 2′, P : a=119° 30′, M : a=127° 59′. Another form, similar to fig. 51, Pl. I., except that the planes a, are so extended as to produce four sided pyramids at each extremity of the crystal. Sometimes the crystals are nearly cylindrical and contracting in size towards each end, have a barrel-like shape. *Cleavage* highly perfect, parallel with P; less so parallel with M. The imperfectly crystalline varieties have usually a lamellar composition in the direction of P.

H.=4·5—5. G.=2·335, Haidinger, a variety from Iceland; 2·359, Thomson. *Lustre* of P pearly; of the other faces vitreous. *Streak* white. *Color* white, or grayish; occasionally with a shade of green, yellow, or red. Transparent—opaque. *Fracture* uneven. Brittle.

Its constituents, according to Stromeyer, Berzelius, Turner, and Thomson, are as follow:

	Fassa.	Faroe, Var. Tesselite.	Var. Oxahverite.	Uton.
Silica	51·8643	51·76	50·76	51·008
Lime	25·1992	22·73	22·39	26·236
Potash	5·1369	5·31	4·18	5·888
Fluosil. of Lime	——	3·53	trace.	——
Water	16·0438	16·20	17·36	16·500
	98·2442, S.	99·53, B.	94·69, Turn.	99·634, Th.

It exfoliates before the blowpipe, and ultimately fuses into a white vesicular glass. It melts easily with borax. In nitric acid it separates into flakes, and becomes somewhat gelatinous and subtransparent.

Obs. The term, *tesselite*, was applied by Brewster to a variety from Faroe, presenting nearly a cubical form, which, upon optical examination, exhibits a mosaic-like, or tesselated structure. *Oxahverite* is a pale green variety from the Oxahver springs, near Husavick, in Iceland, where it occurs on calcified wood; it is generally indistinctly crystallized and translucent. *Albin*, of Werner, is a white, opaque variety, found at Aussig, in Bohemia, associated with natrolite.

Greenland, Iceland, the Faroe Islands, and Poonah, in Hindostan, afford fine specimens of apophyllite. It occurs at these localities coating the cavities of amygdaloid, associated with chalcedonic quartz, stilbite, chabazite, &c. At Andreasberg it occurs in silver veins, traversing gray-wacke slate; in the Bannat, associated with Wollastonite. In Fifeshire, it has been found in large transparent crystals, occupying the interior of fossil shells. It is associated with magnetic iron, at Uton, in Sweden. Also at Puy-de-la-Piquette, in Auvergne, where it occurs in crystals in a tertiary limestone, but appears to have been formed by sublimation, caused by the adjoining basaltic rocks, subsequent to the deposition of the limestone.

In America it has been found at Peter's Point and Patridge Island, in the Basin of Mines, Nova Scotia. It here occurs both massive and crystallized, presenting white, reddish, and greenish colors. It is associated with Laumonite, Thomsonite, and other minerals of trap rocks.

Apophyllite was so named in allusion to its highly foliated character, from απο and φυλλον, *a leaf.* Its pearly lustre on the face of perfect cleavage, obtained for it the name of *Ichthyophthalmite*, from the Greek ιχθυς, *a fish*, and οφθαλμος, *an eye.*

LAUMONITE. VULCANUS EFFLORESCENS.

Diatomous Kouphone-Spar, *M.* Diprismatic Zeolite, *J.* Lomonite, *W.* Laumontit, *L.* Laumonit, *H.* Efflorescing Zeolite.

317. *Primary form:* an acute oblique rhombic prism; M : M= 86° 15′, P : M=66° 30′, or 113° 30′. *Secondary form:* similar to fig. 97, Pl. II.; also with the edge between each M and ă replaced. *Cleavage* parallel to the acute lateral edge. Imperfectly crystalline varieties have a radiating or diverging structure.

H.=3·5—4 of the mineral, fresh from its locality. G.=2·3, Haüy. *Lustre* vitreous, inclining to pearly upon the faces of distinct cleavage. *Streak* white. *Color* white, passing into yellow or gray. Transparent—translucent, becomes opaque on exposure. *Fracture* scarcely observable, uneven. Not very brittle.

It consists of

		From Huel Goet.	Skye.
Silica	49·0	48·3	52·04
Alumina	22·0	22·7	21·14
Lime	9·0	12·1	10·62
Water	17·5	16·0	14·92
Carbonic Acid	2·5=100, Vögel.	—— 99·1, Gmelin.	—— =98·72, Con.

Before the blowpipe it intumesces and fuses into a white frothy mass. With borax, it forms a transparent globule. It gelatinizes with nitric or muriatic acids, but is not affected by sulphuric acid, unless heated. If insulated, it acquires negative electricity by friction. On exposure to the air, it loses its water of crystallization, and becomes opaque, and in this state is easily pulverized by the fingers, and often it falls to a powder of itself.

OBS. Laumonite occurs in the cavities of amygdaloid, also in porphyry, and occasionally in veins traversing clayslate with limestone. It was first observed in 1785, in the lead mines of Huel Goet, in Brittany, by Gillet Laumont, after whom it is named.

Its principal localities are the Faroe Islands; Disko, in Greenland; St. Gothard, in Switzerland; in the Fassa-thal, in large masses, exhibiting a radiated structure; at Hartfield Moss, in Renfrewshire, accompanying analcime; in the amygdaloidal rocks in the Kilpatrick hills, near Glasgow; and in several trap rocks of the Hebrides, and the north of Ireland.

Peter's Point, Nova Scotia, affords fine specimens of this species. It is there associated with apophyllite, Thomsonite, and other species of this family.

It has been observed in small quantities in the trap rocks of Connecticut and Massachusetts, and at Phillipstown, New York.

The rapid decomposition to which this mineral is exceedingly liable, may be prevented by dipping the specimen in a thin solution of gum Arabic, by means of which it is preserved from contact with the air.

HARMOTOME. VULCANUS GEMELLUS.

Paratomous Kouphone-Spar, *M.* Staurolite, *Kirwan.* Andreolite. Andreasbergolite. Ercinite. Kreuzstein, *W.* Harmotome, *H.*

318. *Primary form:* a right rectangular prism. *Secondary form:* fig. 1;

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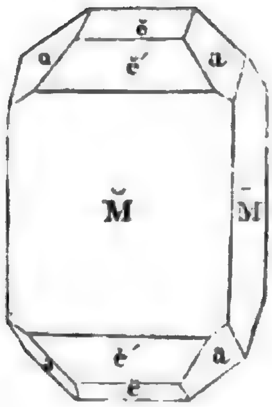

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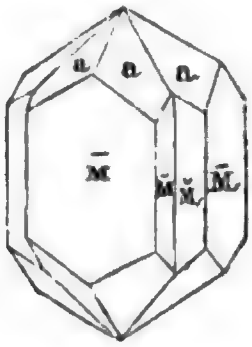


a : a=119° 4′, ĕ : a=149° 32′, $\breve{M}$: e=125° 5′, Phillips. *Cleavage* parallel to $\breve{M}$ and $\bar{M}$ imperfect. *Compound crystals:* the form in fig. 2 is composed of four individuals, united according to composition of the *third kind*, as explained in § 76, 77. These forms are of very frequent occurrence. Harmotome is rarely found massive.

H.=4—4·5. G.=2·4—2·448. *Lustre* vitreous. *Streak* white. *Color* white; passing into gray, yellow, red, or brown. Subtransparent—translucent. *Fracture* uneven, imperfectly conchoidal. Brittle.

It contains, according to Gmelin and Hepel, (Ann. des Mines, x. 257,) Connell and Thomson, (Min. i. 350,)

	Andreasberg.	Strontian.	Strontian.
Silica	56·30	47·04	48·753
Alumina	14·50	15·24	15·100
Barytes	17·52	20·85	14·275
Lime	1·00	0·10	3·180
Potash	—	0·88	2·550
Soda	1·25	0·84	—
Perox. Iron	—	0·24	—
Water	11·69=102·26, G. & H.	14·92=100·11, C.	14·000=97·858, T.

Before the blowpipe, on charcoal, it melts without intumescence into a clear globule. It phosphoresces when heated, giving out a yellow light. It is scarcely attacked by the acids, unless they are heated.

Obs. Harmotome occurs in metalliferous veins traversing gray-wacke, also on gneiss, and in the cavities of amygdaloid.

Strontian, in Argyleshire, affords the finest simple crystals of this species. They occur here disposed on calcareous spar, and are sometimes an inch in diameter. This locality affords also specimens of the compound crystals. These, however, are found more abundantly in a metalliferous vein at Andreasberg, in the Hartz. It also occurs at Oberstein, in Deuxponts, coating the cavities of silicious geodes; at Kongsberg, in Norway, on gneiss; accompanying analcime in the amygdaloid of Dumbartonshire.

PHILLIPSITE. VULCANUS PHILLIPSIANUS.

Staurotypous Kouphone-Spar, *M.* Phillipsite, *Levy.*

319. *Primary form*: a right rectangular prism. *Secondaries*

and *twin crystals*, similar to those of harmotome; a : a=about 123° 30′, and 117° 30′, Levy.

H.=4—4·5. G.=2—2·2. *Lustre* vitreous. *Streak* white. *Color* white, sometimes reddish. Translucent—opaque.

Its constituents, according to Gmelin and Hepel, are as follows:

	Morbourg.	Morbourg.
Silica	48·51	48·02
Alumina	21·76	22·60
Lime	6·26	6·56
Potash	6·33	7·50
Protox. Iron	0·29	0·18
Water	17·23=100·38.	16·75=101·61.

Obs. This species was united with the preceding, which it very much resembles, until Levy pointed out its peculiarities, and gave it the name it bears, in compliment to Mr. Phillips. It differs chemically from harmotome in not containing barytes, but, instead, lime and potash.

Dr. Thomson has separated another species from harmotome, which he calls *Morvenite*, or transparent harmotome, from Strontian. It occurs in rectangular prisms, with deeply replaced edges and angles. According to his measurement $\tilde{M} : e = 124° 47'$, $\tilde{M} : e = 145° 13'$, $e : a = 149° 32'$.

Phillipsite occurs in large translucent crystals in the cavities of amygdaloid, in the Giants' Causeway, in Ireland; in sheaf-like aggregations at Capo di Bove, near Rome. In long crystals aggregated in radiating masses, at Aci Reale, on the eastern coast of Sicily; also among the Vesuvian lavas; and in the island Magee, county Antrim, in minute flesh-red crystals, coating cavities of amygdaloid.

ANALCIME. VULCANUS CUBICUS.

Hexahedral Kouphone-Spar, *M.* Hexahedral Zeolite, *J.* Cubizit, *W.* Analzim, *L.* Sarcolite.

320. *Primary form:* the cube. *Secondary forms:* figs. 14, 15, 16, also fig. 2, and 2 and 5 combined, Pl. I. *Cleavage* parallel to the primary form, but only in traces. Massive varieties have a granular structure.

H.=5—5·5. G.=2·068, Haidinger; 2·278, Thomson. *Lustre* vitreous. *Streak* white. *Color* white; occasionally passing into gray or reddish-white. Transparent—nearly opaque. *Fracture* imperfectly subconchoidal, uneven. Brittle.

It is composed of

	Fassa.	Giants' Causeway.	Kilpatrick.
Silica	55·12	55·60	55·07
Alumina	22·99	23·00	22·22
Soda	13·53	14·65	13·71
Water	8·27=99·91, H. Rose.	7·90=101·15, Thom.	8·22=99·22, Connell.

It fuses before the blowpipe, on charcoal, without intumescence, into a clear glassy globule. It gelatinizes in muriatic acid. It becomes very slightly electric when heated.

Obs. The varieties of this species, which occur under the last two secondary forms above stated, have been separated by the late Dr. Thomson, of Naples, as a distinct species, under the name of Sarcolite. This, however, is unwarranted until analysis shall manifest a dissimilar composition. Their crystalline forms are not inconsistent with the idea of their identity.

The Cyclopean Islands, near Catania, on the Sicilian coast, afford the most perfect pellucid crystals of this species; their form is represented in fig. 14, Pl. I. The same form occurs also in the Tyrol. The form in fig. 16, or the trapezohedron, occurs in Dumbartonshire, the Kilpatrick Hills, Glen Farg. These crystals are generally opaque, and sometimes have a diameter of three or four inches.

Analcime is of frequent occurrence in the Faroe Islands, Iceland, the Vicentine, and elsewhere, in the cavities of amygdaloidal, basaltic, and trap rocks, associated with Prehnite, chabazite, apophyllite, &c. At Arendal, in Norway, it occurs in beds of iron ore; and at Andreasberg, in the Hartz, in silver mines. The cubo-octahedral variety, or sarcolite, occurs among the ancient lavas of Vesuvius, associated with Wollastonite, hornblende, and several species of the zeolite family. The name, Analcime, is derived from *ἀναλκις*, *weak*, in allusion to its weak electric power when heated.

SODALITE. VULCANUS DODECAHEDRUS.

Dodecahedral Kouphone-Spar, *M.* Sodalite, Hauyne, Spinellane, Azurestone, Lapis Lazuli, Ittnerite. Nosian, *Klaproth.* Sodalit, *L.* Auina, *Monticelli.*

321. *Primary form:* the rhombic dodecahedron. *Secondary forms:* figs. 4 and 5, Pl. I. *Cleavage* parallel to the dodecahedral faces, with different degrees of perfection.

H.=5·5—6. G.=2·295—2·378. *Lustre* vitreous. *Streak* white or bluish. *Color* various shades of brown, gray, green, white, and blue; the latter often deep azure blue. Translucent—subtranslucent—nearly opaque. *Fracture* conchoidal or uneven.

Its analyses afford very various results; the following are a few of them:

	Sodalite, from Greenland.		Vesuvius.	*Hauyne.*
Silica	38·52	36·00	35·99	35·48
Alumina	27·48	32·00	32·59	18·87
Soda	25·50	25·00	26·55	—
Potash	—	—	—	15·45
Muriatic Acid	3·00	6·75	5·30	—
Lime	2·70	—	—	12·00
Oxyd of Iron	1·00	0·25	—	1·16
Sulphuric Acid	—	—	—	12·39
Water	—	—	—	1·20
	98·20, Ekeberg.	100·00, Thom.	100·43, Arfwed.	96·55, Gmelin.

	Spinellane.	*Lapis-Lazuli.*	*Ittnerite.*
Silica	43·0	49·0	34·016
Alumina	29·5	11·0	28·400
Soda	19·0	8·0	11·288
Potash	—		1·565
Lime	1·5	16·0	5·235
Peroxyd of Iron	2·0	4·0	0·616
Sulphuric Acid	1·0	2·0	—
Gypsum	—	—	4·891
Common Salt	—	—	1·618
Water	2·5	trace.	10·759
Sulphuretted hydrogen	—	—	
	96·5, Klap.	90·0, Gmelin.	98·388

These different varieties behave very differently under the blowpipe. All, however, gelatinize with nitric acid.

Obs. *Sodalite* includes the white and light green crystallized varieties of this species; *Hauyne*, the bright blue or occasionally asparagus green crystallized specimens; *Spinellane*, or *nosian* of Klaproth, the dark ash-gray translucent crystals; and *Lapis-Lazuli*, the specimens almost always massive, of a rich Berlin or azure-blue color.

The sodalite from Greenland, is partly fused, though with extreme difficulty, in the reducing flame of the blowpipe. Its G.=2·29. The sodalite from Vesuvius, where it occurs in white translucent, lengthened dodecahedral crystals, form a colorless glassy globule; its G.=2·38. Sodalite occurs massive, of a gray color, imbedded in trap at the Kaiserstuhl, in the Brisgau; this variety has been denominated *Ittnerite*. *Hauyne* fuses slowly in the blowpipe flame, into an opaque mass. With borax it effervesces, and forms a transparent vitreous globule, which turns yellow on cooling. Its G.=2·68—3. It does not form a jelly with acids as easy as the other varieties. It occurs in the Vesuvian lavas, also in the vicinity of Rome, and at Niedermannich, near Andernach, on the Rhine. *Spinellane* is infusible. G.=2·28. It is met with in the drusy cavities of glassy feldspar, at the lake of Laach, near Andernach. *Lapis-Lazuli* fuses into an opaque globule, and, if previously calcined and reduced to powder, is decolorated by acids. G.=2·95. It is brought from Persia, China, Siberia, and Bucharia, where it is associated with feldspar and limestone, and contains often scales of mica and particles of pyrites. On the banks of the Indus, it occurs disseminated in grayish limestone. The richly colored specimens of Lapis-Lazuli, are highly valued as a material for costly vases and ornamental furniture. Magnificent slabs of it are contained in some of the Italian churches. It is also employed in the manufacture of Mosaics, and its powder forms a highly prized and exceedingly durable paint, called ultramarine.

LEUCITE. VULCANUS TRAPEZOHEDRUS.

Trapezoidal Kouphone-Spar, *M.* Dodecahedral Zeolite or Leucite, *J.* Amphigène, *H.* White Garnet. Leuzit, *W.*

322. *Primary form:* a rhombic dodecahedron, fig. 7, Pl. I. *Secondary form:* fig. 16, a tetragonal tris-octahedron. *Cleavage* very imperfect parallel to the primary planes, (e, fig. 18, Pl. I,) and also to the faces of the cube, (P in fig. 15, Pl. I.) Surface of the crystals even, though seldom shining. Occurs rarely in irregular forms of a granular structure.

H.=5·5—6. G.=2·483—2·49. *Lustre* vitreous. *Streak* white. *Color* ash-gray or smoke-gray, grayish-white. Translucent—nearly opaque. *Fracture* conchoidal. Brittle.

According to Klaproth (Beitrage, ii. 42) and Arfwedson, (Afhandlingar, vi. 256,) it contains,

	Vesuvius.	Albano.		Albano.
Silica	53·750	54	58·70	56·10
Alumina	24·625	23	19·95	23·10
Potash	21·350	22	21·40	21·15
Oxyd of Iron	——	—	0·40	0·95
Lime	——=99·725, K.	—=99, K.	1·35=91·80, Arf.	——=101·30, Arf.

Infusible before the blowpipe except with borax or carbonate of lime, with which it melts with difficulty into a clear globule. Its powder changes the blue tincture of violets to green.

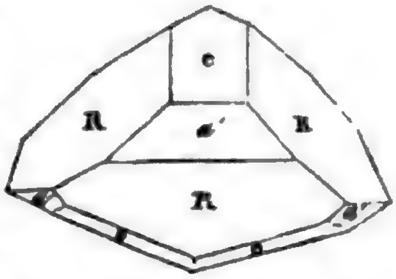
Obs. Leucite is abundant in the ancient lavas of the Rieden country, between the Laacher Lee and Andernach, on the Rhine. Vesuvius, however, presents the finest and largest crystallizations. In the vicinity of Rome, at Boghetto, to the north, and Albano and Frescati to the south, some of the older lavas are so thickly studded with this mineral, as to appear almost entirely composed of it. The crystals generally present the secondary form, above mentioned.

The Leucitic lava of the neighborhood of Rome, has been used for the last 2000 years at least, in the formation of mill stones. Mill stones of this rock have lately been discovered in the excavations at Pompeii.

Leucite is derived from λευκος, *white*, in allusion to its color; and because its form is similar to a common variety of the garnet, it has been designated *white garnet*.

CHABAZITE. VULCANUS RHOMBOHEDRUS.

Rhombohedral Kouphone Spar, *M.* Rhombohedral Zeolite or Chabasite, *J.* Chabasie, *P. L.* and *H.* Schabasit, *W.* Chabasin, *Haus.*



323. *Primary form:* a slightly obtuse rhombohedron; R : R=94° 46′. *Secondary form:* R : e=137° 23′, R : *a*′=126° 26′, a′ : a′ (over R)=72° 53′, e : e=125° 13′. *Cleavage* rather indistinct, parallel to R.

H.=4—4·5. G.=2·088, Thomson, transparent crystals from Kilmalcolm; 2·100, Haidinger, crystal from Bohemia; 2·472, Lehunt, an Irish specimen containing much soda. *Lustre* vitreous. *Streak* white. *Color* white, occasionally reddish, rarely yellowish. Transparent—translucent. *Fracture* uneven; brittle.

It contains, according to Berzelius, Arfwedson, Thomson, and Lehunt,

	Eustafsberg.	Faroe.	Kilmalcolm.	Scotland.
Silica	50·65	48·30	48·756	49·17
Alumina	17·00	19·28	17·440	18·90
Lime	9·73	8·72	10·468	——
Potash	1·70	2·50	1·548	Soda 12·19
Water	19·50=98·58, B.	20·00=98·80, A.	21·720=99·932, T.	19·73=99·99, L.

The last specimen contains soda in the place of potash. Before the blowpipe it fuses into a white spongy mass. It is not acted upon by acids. The opaque crystals become translucent in oils.

Obs. Amygdaloid is the principal repository of chabazite. It also occurs between the layers of gneiss and mica slate.

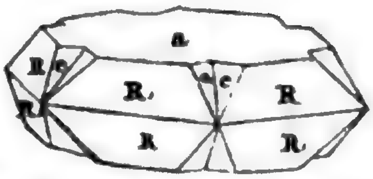
At the Faroe Islands, Greenland, and Iceland, fine crystallizations of this species are found, associated with chlorite and stilbite. Also at Aussig, in Bohemia, in a kind of greenstone, (*graustein* of Werner,) the Giants' Causeway; Kilmalcolm, Renfrewshire; Isle of Skye. In Nova Scotia, in amygdaloid, it occurs of a wine-yellow, or flesh-red color, in fine crystals, often highly modified; it is associated with Heulandite, analcime, and calcareous spar.

The trap region of Connecticut and Massachusetts affords occasional specimens of this mineral. In the same rock it also occurs near Baltimore, Md. At Hadlyme, Conn., it is met with on gneiss.

The name chabazite was derived by Box d' Antic, from the Greek word χαβαζιος, the name of one of the twenty stones, celebrated for their virtues, in the poem ascribed to Orpheus, entitled περι λιθων.

LEVYNE. Vulcanus Levyanus.

Macrotypous Kouphone-Spar, *M.* Levyne, *Brewster's* Jour. II., 332.



324. *Primary form:* a rhombohedron; R : R=79° 29′. *Cleavage* indistinct parallel with R. *Compound crystals:* annexed figure; R : R′=125° 12′, a : e=136° 1′, R : a=117° 29′, composition *of the third kind,* it being parallel to a plane on the vertical solid angle. Plane a, usually uneven, and often curved.

H.=4. G.=2·161, Thomson; 2·198. *Lustre* vitreous. *Streak* white. *Color* white; sometimes reddish. Subtransparent—opaque. *Fracture* subchonchoidal. Brittle.

Its composition, according to Thomson (Min. i. 336) and Berzelius, (Kong. Vet. Acad. Handl., 1824, p. 356,) is as follows:

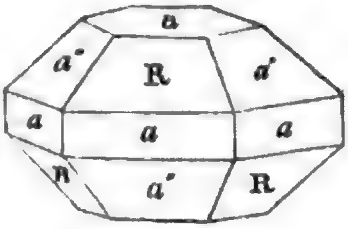
Silica	48·750	48·00
Alumina	20·333	20·00
Lime	8·833	8·35
Magnesia	0·770	0·40
Soda	3·333	2·75
Water	20·000	19·30
Potash	trace=98·019, T.	0·41=99·21, B.

Before the blowpipe it intumesces and whitens. With biphosphate of soda it yields a transparent globule, containing a skeleton of silica, which becomes opaque on cooling. It is unaltered in acids.

Obs. Levyne occurs in trap, with natrolite and mesotype, at the little Deer Park of Glenarm, county Antrim; also at Skagastrand, in Iceland; at Dalsnypen, in Faroe, accompanied by chabazite, analcime, and Heulandite; Godhavn, in Disco Island, Greenland; occasionally in large reddish opaque crystals at Hartfield Moss, in Renfrewshire.

GMELINITE. Vulcanus expolians.

Hexagonal Kouphone-Spar, *Haid.* Hydrolite, *De Drée.* Sarcolite, *Vauquelin.* Gmelinite, *Brewster's* Jour. II. 262.



325. *Primary form:* a rhombohedron. *Secondary form:* *a* : R or *a* : *a″*=131° 48′, a : R or a : *a″*=138° 12′, R : *a″* (over *a*)=83° 36′. *Cleavage* apparent parallel to R, the face of a rhombohedron, though obtained with difficulty. Planes *a* horizontally striated.

H.=4—4·5. G.=2·054; 2·169, Hayes; variety *Ledererite.* *Lustre* vitreous. *Streak* white. *Color* white, passing into flesh-red. Transparent—translucent. *Fracture* uneven. Very brittle.

Its constituents, according to Thomson, Vauquelin, and Hayes, are as follow:

	From Antrim.	Castel.	Cape Blomidon.
Silica	39·896	50·00	49·47
Alumina	12·968	20·00	21·48
Peroxyd of Iron	8·270	——	0·14
Potash	9·000	——	Phosphor. acid 3·48
Water	29·866	20·00	8·58
Lime	——	4·25	11·48
Soda	——=100, Thom.	4·25=98·50, Vauq.	3·94=98·57, H.

Though the first two analyses differ in some respects, yet the proportion of silica to the alumina is nearly the same.

When held in the flame of a candle it exfoliates and flies off in numerous scales. "Small portions," says David Brewster, "gradually raise themselves, and after standing on their ends, as if they were under the influence of electricity, they are propelled with violence from the fragment." In the blowpipe flame it increases in bulk, but does not melt into a glass.

Obs. This species includes the *Hydrolite* of De Drée, and the *Sarcolite* of Vauquelin; also the *Ledererite* of Jackson, (Silliman's Am. Journal, xxv. 80,) which is described as presenting the same form, and nearly identical angles, and in other respects is similar to this species.

Gmelinite occurs in the cavities of amygdaloidal rocks at Montecchio Maggiore, and at Castel, in the Vicentine; also in the county Antrim; at the Deer Park of Glenarm, of a white color, and at the Island Magee, near Larne, of a pale flesh-red tinge.

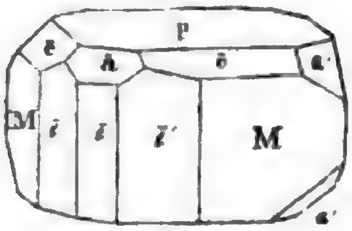
Ledererite was obtained by Messrs. Jackson and Alger, at Cape Blomidon, in Nova Scotia, where it occurs in basalt, associated with stilbite, mesotype, and analcime. The crystals are usually implanted in the analcime, or stilbite.

DATHOLITE. Vulcanus dystomus.

Prismatic Dystome-Spar, *M.* Borate of Lime, *P.* Borosilicate of Lime, *Thom.* Datholith, *W.* Esmarkite, *Haus.* Datolite. Humboldtite, *Levy.* Chaux Boratée Silicieuse, *H.*

326. *Primary form:* an acute oblique rhombic prism; M : M =77° 30′. *Secondary forms:*

1.



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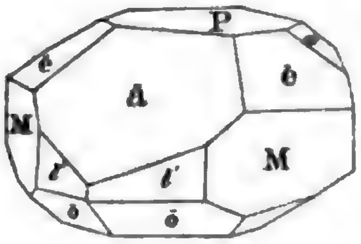


P : e=91° 41′, $\breve{e}'$: $\breve{e}'$=116° 9′, $\breve{e}$: $\breve{e}'$=148° 4½′, M : e=128° 45′, M : $\breve{e}'$=150° 40½′ *Cleavage* parallel to M and also $\breve{e}$, or the shorter diagonal, but not distinct. *Imperfect crystallizations:* botryoidal and globular shapes, composed of a columnar structure; also divergent and radiating forms, consisting of delicate columnar particles; also granular.

H.=5—5·5. G.=2·989, Haidinger; a crystal from Arendal. *Lustre* vitreous, often inclining to resinous on the surface of fracture; sometimes also pearly. *Streak* white. *Color* white; sometimes inclining to gray, green, yellow, or red; rarely of a dirty olive-green or honey-yellow tinge. Translucent. *Fracture* uneven, subconchoidal. Brittle.

It contains, according to Klaproth (Beit. iv. 356, and v. 123) and Stromeyer, (Poggend. Ann. xii. 157,) and Du Menil,

	Var. Botryolite.			From Hartz.
Silica	36·5	36·0	37·36	38·51
Boracic acid	24·0	39·5	21·26	35·59
Lime	35·5	13·5	35·67	21·34
Water	4·0	6·5	5·71	4·60
Oxyd of Iron	—=100, K.	1·0=96·5, K.	—100·00, S.	—100·04, Du M.

The variety *Botryolite*, which included the botryoidal or reniform specimens, having a fibrous structure, differs much in composition from the crystals of datholite, and probably will hereafter form a distinct species. The observations which have heretofore been made, lead, however, to the conclusion, that they are merely different forms of the same species.

Datholite (including its varieties) becomes friable in the flame of a candle. Before the blowpipe it becomes opaque, intumesces, and melts into a glassy globule. It dissolves readily in, and gelatinizes with, nitric acid.

Obs. Datholite is found in amygdaloid and gneiss; sometimes also in beds of iron ore in primitive rocks. In the latter situation both varieties are found at Arendal, in Norway. The variety *Humboldtite*, which was instituted as a distinct species by Levy, occurs in agate balls at the Seisen Alp, in the Tyrol. Datholite is met with also in the valley of Glen Farg, Perthshire. The state of New Jersey, at Patterson, and Connecticut, at Middlefield, and near Hartford, afford finely crystallized specimens of this species, at each of which localities it occurs in amygdaloid.

PECTOLITE.

Pektolite, *Kobell*. Kastner's Archiv, XIII. 385.

327. Spheroidal masses, consisting of divergent fibres radiating from a centre.

H.=4—5. G.=2·69. *Lustre* of the surface of fracture pearly. *Color* grayish. Opaque.

It contains, according to Kobell, (Kastner's Archiv, xiii. 385,) Silica 51.3, Lime 33·77, Soda 8·26, Potash 1·57, Water 8·89, Alumina and Oxyd of Iron 0·9=104·69. Fuses into a white transparent glass.

Obs. Occurs in large masses on Monte Baldo, in Southern Tyrol, and at Monzoni, in the Fassa-thal. It resembles some radiating varieties of Mesotype.

BREVICITE.

328. Occurs in regular prismatic crystals; also massive, structure foliated and radiated. *Color* white; often crossed by bands of a deep dirty red color.

It contains, according to M. Sonden, Silica 43·88, Alumina 28·39, Soda 10·32, Lime 6·88, Magnesia 0·21, Water 9·63=99·31.

Obs. This species was sent to Berzelius by M. Ström, from Brevig, in Norway, and was named by the former from its locality.

POOHNAHLITE.

Brooke, Annals of Philosophy, August, 1831.

329. *Primary form:* a right rhombic prism; M : M=92° 20′.

H.=5—5·5. *Lustre* vitreous. *Color* white. Transparent—translucent.

Obs. This species accompanies the fine apophyllites, stilbites, &c. at Poohnah, in Hindostan. It much resembles natrolite; but its crystals traverse the matrix, instead of forming groups in cavities, and have not been observed with perfect terminations.

BERZELINE.

Necker de Saussure, in Leonhard's Jahrbuch der Mineralogie, II. 441.

330. In extremely minute crystals. *Lustre* of surface of fracture, vitreous. *Color* white. Slightly translucent.

It fuses with difficulty into a pale glass. With acids, it forms a jelly.

Obs. It accompanies crystals of black garnet, and pinchbeck-brown mica, in the drusy cavities of an augitic rock, at Galloro, near La Ricia, in the Roman states.

MONTICELLITE.

Brooke, Annals of Philosophy, October, 1831.

331. *Primary form:* a right rhombic prism; M : M=132° 34′. *Cleavage* not apparent.

H.=5—7. *Color* yellowish; sometimes nearly transparent, or colorless.

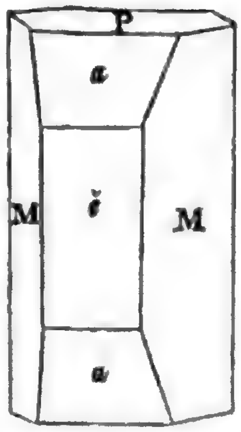
It gelatinizes in muriatic acid; fuses with difficulty before the blowpipe.

Obs. Occurs at Vesuvius in small imbedded crystals, in a crystalline carbonate of lime, associated with particles of black mica, and minute crystals of pyroxene. It was named by Brooke, in honor of the celebrated Neapolitan mineralogist, Monticelli.

PREHNITE. Clasistylus acrotomus.

Axotomous Triphane-Spar, *M.* Prismatic Prehnite, *J.* Koupholite.

332. *Primary form:* a right rhombic prism; M : M=99° 30′. *Secondary form:* M : M=80° 30′, M : ĕ=130° 15′. P : *a*=105° 30′. *Cleavage* distinct parallel with P. Tabular crystals often unite by P, so as to produce what appears to be a single crystal broken in several places, and somewhat rounded at its extremities. *Imperfect crystallizations:* reniform, globular, and stalactitic shapes, with a crystalline surface, and imperfectly columnar or lamellar, strongly coherent structure; also granularly massive structure, sometimes impalpable.



H.=6—6·5. G.=2·8—2·953. *Lustre* vitreous, except on P, whose lustre is pearly, especially of a face obtained by cleavage. *Streak* white. *Color* various shades of green, passing into white and gray. Subtransparent—translucent. *Fracture* uneven. Somewhat brittle.

It contains, according to Klaproth, Gehlen, Thomson, and Lehunt,

	A foliated var.	Fibrous var.	Fib. light-green.	White var. Edinb.
Silica	43·80	43·00	43·60	43·048
Alumina	30·33	23·25	23·00	23·840
Lime	18·33	26·00	22·33	26·164
Protox. Iron	5·66	2·00	2·00	0·640
Protox. Mang.	——	0·25	——	0·416
Potash and Soda	——	——	——	1·028
Water	1·16	4·00	6·40	4·600
	99·28, K.	98·50, G.	97·33, T.	99·736, L.

Before the blowpipe, on charcoal, it froths and melts into a slag of a light-green color. With borax it forms a transparent bead. In dilute muriatic acid, it dissolves slowly, but does not gelatinize, and leaves behind a flaky residue. When heated, it exhibits electric polarity.

Obs. Prehnite was first found at the Cape of Good Hope by Colonel Prehn. It has since been discovered in fine crystallizations in granite, gneiss, and trap rocks. At St. Chrystophe, in Dauphiny, it is associated with axinite and epidote; it also occurs in the Fassa valley, Tyrol; in Saltzburg; at Friskie Hall and Campsie, in Dumbartonshire; and at Hartfield Moss, in Renfrewshire, in veins traversing trap, associated with analcime and Thomsonite; also at Corstorphine Hill, the Castle and Salisbury Crag, near Edinburgh.

In the United States, finely crystallized specimens have been obtained at Farmington and Middletown, Conn. It occurs in small quantities in gneiss, at Bellows' Falls, Vt., and in Sienite, at Charlestown, Mass. Handsome polished slabs of this mineral have been cut from large masses brought from China.

NEPHRITE. Nephrus amorphus.

Uncleavable Nephrite-Spar, *Haid.* Common Jade, *P.* Jade Nephritique, *H.* Talcum Nephriticum, *Linn. Wern.*

333. Massive; fine granular, or impalpable composition.

H.=6·5—7·5. G·=2·932—3·024. *Lustre* vitreous. *Streak* white. *Color* leek-green, passing into blue, gray, and white. Translucent—subtranslucent. *Fracture* coarse, splintery. Very tough.

It contains, according to Kastner and Bowen,

			From Smithfield, R. I.
Silica	50·50		41·688
Magnesia	31·00		34·631
Alumina	10·00		0·562
Ox. Iron	5·50		1·747
Ox. Chrome	0·05	Lime	4·250
Water	2·75=100·80, K.		13·417=96·295, B.

The dissimilarity between the analysis of the Smithfield variety and the preceding, may be owing, in part, to its intermixture with calcareous spar, in which it is imbedded.

It is infusible, *per se*, before the blowpipe, but becomes white; with borax it forms a clear glass.

Obs. Jade was originally brought from China and Egypt. A fine sky-blue variety occurs in the primitive limestone of Smithfield, R. I., and a greenish and reddish-gray variety in the same species of rock at Easton, Penn.

The name *Nephrite* is derived from νεφρος, a *kidney*; it was supposed to be a cure for diseases of the kidney.

SAUSSURITE. Nephrus peritomus.

Prismatic Nephrite-Spar, *Haid.* Jade Tenace, Felspath Tenace, *H.*

334. *Imperfectly crystallized : cleavage* in two directions parallel to the lateral faces of a rhombic prism of 124°, nearly. Composition often granular, impalpable ; strongly coherent.

H.=5·5—6. G.=3·256, a granular variety from Piedmont ; 3·342, a compact variety from the Pays de Vaud. *Lustre* pearly, inclining to vitreous upon the faces of cleavage ; also resinous in some specimens, particularly the massive. *Streak* white. *Color* white, passing into greenish-white, mountain-green, or ash-gray. *Fracture* uneven, splintery. Extremely tough, and difficultly frangible.

It contains, according to Klaproth and Saussure,

Silica	49·00		44·00
Alumina	24·00		30·00
Lime	10·00		4·00
Magnesia	3·75	Potash	0·25
Oxyd of Iron	6·50		12·50
Soda	5·50		6·00
Ox. Manganese	——		0·05
Loss	0·75=99·55, K.		3·20=100, S.

Before the blowpipe it fuses with great difficulty into a white glass.

Obs. Saussurite occurs in primitive regions, and with hornblende and augite constitutes the rocks called gabbro and euphotide. It was first found on the borders of the lake of Geneva, by Saussure Senior, whose name it bears. It also occurs at Monte Rosa and its vicinity, in Corsica, in Greenland, at Madras, and elsewhere, as a constituent of the above rocks.

In the United States, at Canaan, Conn., it composes a mountain some miles in extent.

PETALITE. Petalus rhombicus.

Prismatic Petaline-Spar, *M.* Berzelite.

335. *Imperfectly crystallized. Cleavage* parallel to a prism of 95°, nearly. Structure sometimes columnar, occasionally impalpable, usually strongly coherent.

H.=6—6·5. G.=2·42, Arfwedson ; 2·45, Dr. Clarke ; 2·426, C. G. Gmelin. *Lustre* vitreous and glistening ; pearly on the faces of perfect cleavage. *Streak* white. *Color* white, or gray, with occasionally a reddish or greenish tinge. Translucent. *Fracture* imperfectly conchoidal. Brittle.

It contains, according to Arfwedson (Afhand. vi. 145) and Gmelin, (Ann. Phil. xv. 343,)

Silica	79·212	74·17
Alumina	17·225	17·41
Lithia	5·761	5·16
Lime	trace	0·32
Water	——=102·198, A.	2·17=99·23, G.

Gently heated, it emits a blue phosphorescent light. In the blowpipe flame, on charcoal, it becomes glassy, subtransparent, and white, and melts only on the edges. With borax, it forms a clear, colorless glass. When boiled in acids, it is partly decomposed.

Obs. Petalite occurs near Stockholm, at the iron mine of Uton, accompanying the lepidolite variety of mica, turmaline, spodumene, and quartz; also at Bolton, Mass., where it is associated in a lime quarry with scapolite, sphene, and pyroxene.

Lithia was first discovered in this mineral by Arfwedson. The name *petalite* is derived from πεταλον, *a leaf.*

TURQUOIS. Lazulus amorphus.

Uncleavable Azure-Spar, *M.* Calaite. Mineral Turquois. Agaphite. Johnite. Birouza *of the Persians.* Callais, probably, of *Pliny.*

336. In reniform masses. *Cleavage* none.

H.=6. G.=2·83—3·00. *Lustre* somewhat waxy, internally dull. *Streak* white. *Color* a peculiar bluish-green. Feebly subtranslucent—opaque. *Fracture* small conchoidal.

Its constitution, according to John's analysis, (Ann. des Mines, 2d ser. iii. 231,) is as follows:

Alumina	44·50
Phosphoric Acid	30·90
Oxyd of Copper	3·75
Protoxyd of Iron	1·80
Water	19·00=99·95.

Berzelius states that he obtained in his analysis of this mineral, phosphate of alumina, phosphate of lime, silica, oxyd of iron, and copper.

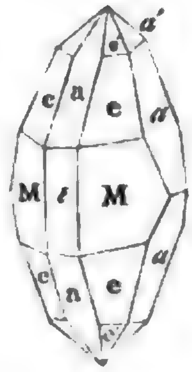
It becomes brown in the reducing flame of the blowpipe, and colors it green, but is infusible; it fuses readily, however, with borax or salt of phosphorus. It is insoluble in muriatic acid, and thus may be distinguished from other species called by the name of Turquois.

Obs. This species occurs only in a mountainous district in Persia, not far from Nichabour. According to Agaphi, the only naturalist who has visited the locality, turquois occurs in veins which traverse the mountain in all directions.

It receives a fine polish, and is valued for ornamental purposes; and when finely colored, is highly esteemed as a gem. The Persian king is said to retain for his own use all the larger and finely tinted specimens.

Pliny remarks concerning the Callaïs, which appears to be identical with the turquois, that it occurred of a pale-green (e viridi pallens) color, and that its finest color was emerald. He states, also, that its form was usually round, and that it was found in Asia, projecting from the surface of inaccessible rocks, whence it was obtained by means of slings.

LAZULITE. Lazulus rhombicus.



Prismatic Azure-Spar, *M.* Azurite, *P.* Azurestone. Hydrousdiphosphate of Alumina and Magnesia, *Thom.*

337. *Primary form:* a right rhombic prism; M : M=91° 30′. *Secondary form:* M : ē=135° 45′, M : e=158° 10′, M : e′=140° 46′, *a* : *a*=120° 40′, *a* : *a*′=150°, ē : a=150° 45′, a : e=138° 45′. *Cleavage* indistinct parallel with M. Occurs also granularly massive; particles strongly coherent.

H.=5—6. G.=3·057. *Lustre* vitreous. *Streak* white. *Color* various shades of azure-blue; commonly of a fine deep blue, viewed in one direction, and a pale greenish-blue, at right angles with the same direction. Subtranslucent—opaque. *Fracture* uneven. Brittle.

According to Fuchs (Schweig. Jour. xxiv. 373) it consists of

Phosphoric Acid	41·81
Alumina	35·73
Magnesia	9·34
Silica	2·10
Protoxyd of Iron	2·64
Water	6·06=97·68.

It slightly intumesces before the blowpipe, assumes at a high heat a glassy appearance, but does not fuse. With borax, it yields a clear colorless globule.

Obs. It occurs both massive and crystallized in narrow veins, traversing clay slate, in the torrent beds of Schlamming and Radelgraben, near Werfen, in Saltzburg. It is also found near Vorau, in Styria, whence it has been called Voraulite.

BLUE SPAR. Lazulus triclinatus.

Prismatoidal Azure-Spar, *M.* Feldspath bleu, *H.*

338. Crystallization undetermined. Commonly occurs in indistinct crystals and masses. *Cleavage* imperfect; sometimes observable in one direction, and apparently in traces in two other directions oblique with the first.

H.=5·5—6. G.=3·024, Haidinger. *Lustre* vitreous. *Streak* white. *Color* smalt-blue, inclining sometimes to white or green. Subtranslucent—opaque. Fracture uneven.

According to Brandes, its constituents are,

Phosphoric Acid	43·32
Silica	6·50
Alumina	34·50
Magnesia	13·56
Lime	0·48
Protoxyd of Iron	0·80
Water	0·50=99·66

Before the blowpipe it loses its color, but is infusible, *per se*. With borax, it dissolves slowly and with difficulty. With boracic acid and iron wire, it affords a globule of phosphuret of iron.

Obs. Blue spar occurs, imbedded in quartz and mixed with mica, in the valley of Freschnitz, near Krieglach, on the Mürz, in Upper Styria; also at Thorenburg, at the foot of the Wechsel mountain, in Lower Austria.

BIOTINE.

Biotina, *Monticelli*, Mineralogia Vesuviana, 438.

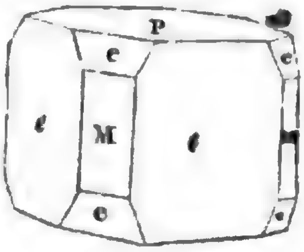
339. Scratches glass. G.=3·11. *Lustre* splendent. *Color* white or yellowish. Transparent and limpid. *Fracture* vitreous, inclining to conchoidal; exhibits double refraction.

Is not affected by the blowpipe, but partly soluble in nitric acid.

Obs. This mineral has been observed by Sig. Monticelli, among the volcanic debris of Vesuvius. Its superior brilliancy readily distinguishes it from its associated minerals. It was named in honor of M. Biot.

SOMERVILLITE.

Brooke, Quar. Jour. of Science, XVI. 275.



340. *Primary form:* a right square prism; *Secondary form:* the annexed figure, with the edge M : *e* replaced; M : *e*=135°, P : e=147° 5′, e : M=122° 55′. *Cleavage* perfect parallel with P.

H. under 6. *Lustre* vitreous. *Color* pale dull yellow.

It decrepitates before the blowpipe, and fuses, *per se*, into a gray colored globule, and with borax into a transparent one.

Obs. Somervillite accompanies black mica and other minerals, in the ancient scoria of Vesuvius. It differs from idocrase in decrepitating before the blowpipe, and in not affording a greenish globule by fusion. This species was first determined by Brooke, and named in compliment to Dr. Somerville.

NEPHELINE. SPATUM HEXAGONUM.

Rhombohedral Feldspar, *M.* Rhomboidal Feldspar, *J.* Sommite, *P.* Davina, and Nefelina, *Monticelli.* Davyne. Covellonite. Beudantite.

341. *Primary form:* a hexagonal prism. *Secondary form:* fig. 125, Pl. II. M : *e*=150°, P : e=134° 3′, Phillips. *Cleavage* parallel with P and M, both indistinct.

H.=5·5—6. G.=2·4—2·56. *Lustre* vitreous; somewhat opalescent and pearly in some varieties. *Streak* white. *Color* white or yellowish. Transparent—opaque. *Fracture* conchoidal. Brittle.

It contains, according to Gmelin, Arfwedson, and Monticelli,

			Var. Davina.
Silica	43·36	44·11	42·91
Alumina	33·49	33·73	33·28
Soda	13·36	20·46	——
Potash	7·13	——	——
Moisture	1·39	0·62	7·43
Lime	0·90	——	12·02
Ox. Mang.	1·50 =101·03, Gm.	——	1·25
Ox. Iron		——=98·92, Arf.; loss.	3·11=100, Mont.

The variety Davyne, agrees nearly in composition with nepheline, and is identical in crystallization. M : e′ (of Davyne) is given at 115° 33′, from which, by calculation, we find M : e (of nepheline) =134° 8′, which is nearly the angle of nepheline, obtained by observation.

Before the blowpipe, on charcoal, the edges of the fragment of nepheline are rounded; perfect fusion cannot be effected. Fragments thrown in nitric acid lose their transparency, and assume a nebulous appearance. This character gave rise to the name nepheline, from *νεφελη, a cloud.* Davyne is described as acting somewhat differently in the blowpipe flame. Alone, before the blowpipe, it fuses with effervescence into a white opaque and somewhat porous globule. With nitric acid it effervesces and forms a jelly.

Obs. Both varieties of this species occur at Vesuvius, in the ancient lavas, associated with garnet, mica, idocrase, Wollastonite, &c. The collection of Sig. Monticelli contains some splendid specimens of this species. Nepheline has also been found at Capo di Bove, near Rome, and in Clinkstone, at Katzenbuckel, near Heidelberg. Davyne was named in compliment to Sir Humphrey Davy.

HERSCHELLITE. Spatum Herschellianum.

Ann. of Philosophy, 2d ser. X. 361.

342. *Primary form:* a hexagonal prism. *Cleavage* perfect, and easily obtained parallel with P.

H.=4·5. G.=2·11. *Color* white. Translucent—opaque.

According to the trials of Dr. Wollaston, it contains Silica, Alumina, and Potash.

Obs. It occurs in the cavities of trap at Aci Reale, near Catania, in Sicily, associated with Phillipsite. The crystals are sometimes isolated, but generally aggregated in a manner similar to those of Prehnite.

ELÆOLITE. Spatum oleaceum.

Fettstein, *W.* Pierre Grasse. Elaolite, *Allan.* Lythrodes. Sodaite.

343. *Imperfectly crystallized. Cleavage* parallel to the base and faces of a right rhombic prism of 112° and 68°, nearly.

H.=5·5—6. G.=2·546—2·618. *Lustre* resinous. *Color* dark-green, bluish-gray, brownish, or brick-red. Some varieties are opalescent, when cut and polished. Translucent. *Fracture* conchoidal.

It contains, according to Gmelin (Schweig. Jahrb. vi. 89) and Vauquelin, (Tableau Comp. p. 228,)

Silica	44·190	44·00
Alumina	34·424	34·00
Soda	16·874	16·50
Potash	4·733	
Lime	0·519	0·12
Magnesia	0·687	—
Perox. Iron	0·652	4·00
Water	0·600=102·679, G.	—=98·62, V.

Before the blowpipe it fuses into a white enamel. In a powder it gelatinizes readily with acids.

Obs. Elæolite occurs only in Norway, imbedded in the Zircon-Sienite of Laurvig, Stavern, and Fredrickswarn. The opalescence of the pale blue variety renders it somewhat valuable for ornamental purposes.

The name elæolite is derived from *ελαιον*, *oil*, in allusion to its oily lustre.

LABRADORITE. Spatum opalescens.

Polychromatic Feldspar, *M.* Labrador Feldspar.

344. *Primary form:* an oblique rhomboidal prism; P : M=93°

28′, P : T=114° 28′, M : T=119° 16′. *Secondary form:* similar to those of albite. *Cleavage* parallel with P and M most distinct; with T indistinct. It occurs also imperfectly crystallized, with the above cleavages.

H.=6. G.=2·69—2·76. *Lustre* of cleavage faces parallel with P pearly, passing into vitreous. *Streak* white, or grayish-white. *Color* gray, brown, or greenish. By changing the position of the specimen, a beautiful *change of colors* may be observed; of these changeable colors, blue and green are the predominant; yellow, red, and pearl-gray, are also apparent. Translucent—subtranslucent.

Its constituents, according to Klaproth (Beitrage iv. 250) and Thomson, (Min. i. 298,) are,

	From Labrador.	From Labrador.
Silica	55·75	55·408
Alumina	26·50	26·920
Lime	11·00	10·892
Protoxyd of Iron	1·25	1·508
Soda	4·00	4·392
Water	0·50=99, K.	0·840=99·96, T.

Before the blowpipe, on charcoal, it becomes glassy and white, but fuses only on the edges. With oxyd of nickel and borax, it affords a blue pearl. It is entirely dissolved by heated muriatic acid, which does not attack either feldspar or albite.

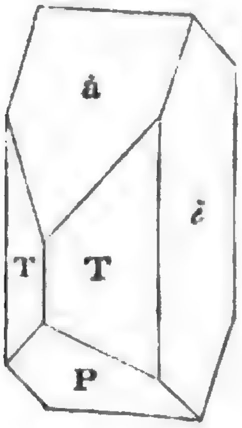
Obs. Labradorite was originally brought from the island of St. Paul, on the coast of Labrador, associated with hornblende, hypersthene, and magnetic iron ore. It exists in magnificent specimens and great abundance in Essex county, N. Y.

FELDSPAR. Spatum orthotomum.

Orthotomous Feldspar, *M.* Prismatic Feldspar, *J.* Felspar. Ice Spar. Ryakonite Adularia, Murchisonite, Leelite, Amausite, Amazonstone, Sunadin, Moonstone, Napoleonite, Lemanite, Courzeranite, Necronite. Feldstein, *Haus.* Feldspath, *H.* Eisspath, *W.*

345. *Primary form:* an oblique rhombic prism; T : T=120°, P : T=67° 15′. *Secondary forms:*

1



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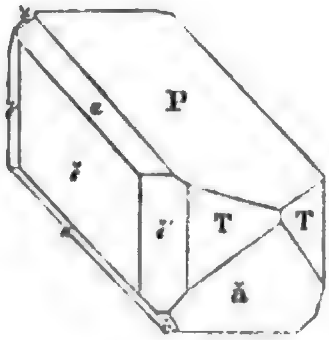

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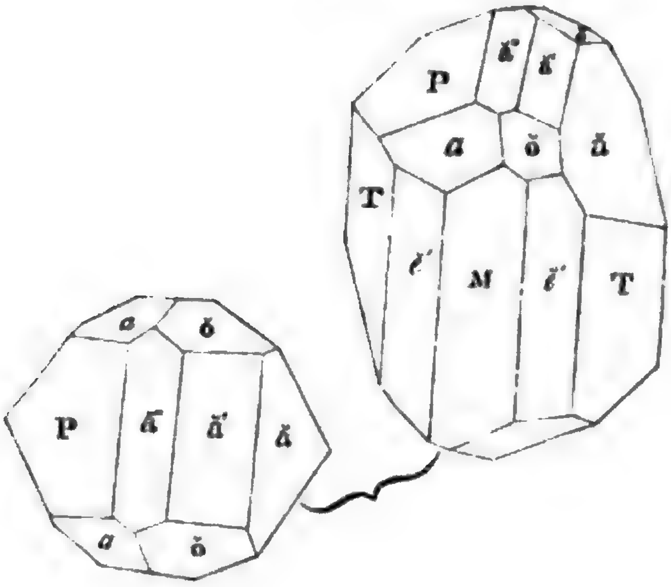
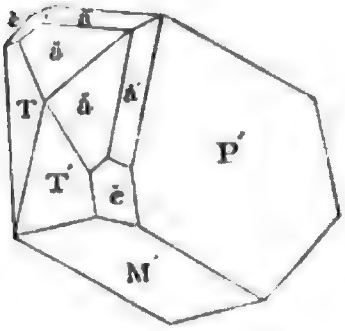


P : á=99° 29′ or 80° 31′, P : ă′=128° 51′, P : ă″=144° 11′. P : a=ĕ : a=135°, T : ĕ=120°, T : ĕ′=150°=ĕ : ĕ′. *Cleavage* parallel with P perfect; with ĕ, or the shorter diagonal, less distinct. *Compound crystals:*

4



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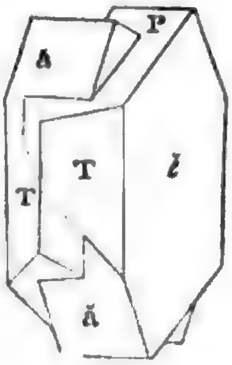

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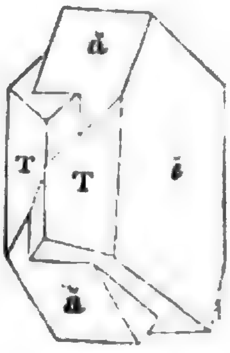


in figs. 5 and 6, composition is of the *first kind*, and has taken place parallel with M. In fig. 4 it is of the *second kind*, and has been effected parallel to the edge P : M.

Massive varieties have usually a granular structure of different degrees of fineness; also sometimes a lamellar composition.

H.=6. G.=2·394—2·581, Rose. *Lustre* vitreous, sometimes inclining to pearly upon the faces of perfect cleavage. *Streak* white, or grayish-white. *Color* white; often gray, reddish-white, flesh-red, greenish-white, green. Transparent—translucent. *Fracture* conchoidal to uneven.

It contains, according to Vauquelin, (Haüy, ii. 592,) Klaproth, (Beitrage, vi. 242,) and Berthier, (Ann. des Mines, vii. 239,)

	Green; Siberia.	Carlsbad.	Fredericksw&auml;rn.	Var. Adularia.
Silica	64	64·50	65·00	64·20
Alumina	20	19·75	20·00	18·40
Potash	14	11·50	12·25	16·95
Lime	2	trace	trace	trace
Oxyd of Iron	—	1·75	1·25	——
Water	—=100, V.	0·75=98·25, K.	0·50=99, K.	——=99·55, B.

Before the blowpipe it fuses with difficulty, and only on the edges. With borax it forms a transparent glass. With carbonate of soda, it fuses into a vesicular glass. It is not acted on by the acids.

Obs. Difference of color and lustre has given rise to distinct names for several of the varieties of this species. *Adularia* includes the transparent or translucent varieties found in primitive rocks. The crystals are often quite large, and are found in the greatest perfection in the highest districts of Savoy; they derive their name from Adula, one of the highest peaks of St. Gothard. The Adularia, which, when polished, exhibits a chatoyant reflection of light, has been called *moonstone*, and when containing interspersed minute scales of mica, *sunstone*. The sunstone reflects a pinchbeck brown tint. This opalescence can be observed only in the direction of a plane which replaces the edge T : T somewhat obliquely.

The more transparent specimens, imbedded in trachytic and volcanic rocks, having a perfect vitreous lustre, have been distinguished by the term *glassy feldspar*. *Ice spar* applies to a similar variety, which occurs crystallized in the Vesuvian lavas. *Common feldspar* includes the more common varieties, which occur as constituents of granite, gneiss, and mica slate rocks. Other varieties are the *Murchisonite* of Levy, which is a yellowish-gray variety from Dawlish and Arran; the *Leelite* of Dr. Clarke, (the Helleflinta of the Swedes,) which occurs at Gryphyttan, in Sweden, with a peculiar waxy lustre, and a deep flesh-red color; and also the *Variolite*, a dark green variety, containing lighter globular particles, from Drae river, in France. *Kaolin* is a term applied to decomposed feldspar. *Courzeranite* is a grayish-black, or blackish-blue variety from the steep defiles of Salleix, in the Pyrenees, termed "des Courzerans," where it occurs imbedded in limestone. Its composition, according to Dufrénoy, (Ann. des Mines, iv. 227,) are, Silica 52·37, Alumina 24·02, Potash 5·52, Lime 11·85, Magnesia 1·40, Soda 3·96=99·12.

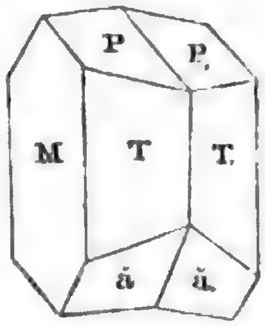
Fine crystallized feldspar is found at Carlsbad and Elbogen, in Bohemia. The twin crystals, represented in figs. 5, 6, are very abundant at the former place, where they occur from two to four inches in length, scattered over the fields, from the decomposition of the granite of the region. Ekatherinenburg, in Siberia; Warmbrunn, in Silesia; Arendal, in Norway; Baveno, in Peidmont; Land's End, &c., are among the interesting localities of this species. At the Mourne mountains of Ireland, fine specimens occur, associated with beryl and topaz. Glassy feldspar occurs in great abundance in the trachyte of the Drachenfels, on the Rhine; also in the lavas which devastated the island of Ischia, near Naples, in 1302. Ice spar is found principally at Vesuvius. It may be obtained in profusion in the valley called Fossa Grande. Porcelain earth, or *kaolin*, occurs at Carclaise and Cigga, in Cornwall; at Aue, near Schneeberg, in Saxony; on the island of Bornholm, in the Baltic; and at Hafnezzell, near Passau, in Bavaria.

In the United States, fine crystals of feldspar are frequently obtained at Rossie and Gouverneur, and the neighboring region, St. Lawrence Co., N. Y. It is usually associated in this region with hornblende, apatite, and scapolite. In a similar situation it is found both perfectly crystallized and cleavably massive, in Buck's Co., Penn., three miles west of Attleboro. It also occurs at Greenfield, near Saratoga, N. Y., and at Haddam, Conn. Large masses of cleavable feldspar may be obtained at Acworth, N. H.; Paris, in Maine, near Ticonderoga; also in still greater abundance in the Highlands of New York, and in Charles Co., Penn. *Kaolin* occurs at Andover, Mass., and Cheshire, Conn. Sunstone is met with at Lyme, Conn.

Feldspar is a necessary material in the manufacture of porcelain. The moonstone and sunstone varieties are often used in jewelry.

PERICLINE. Spatum gemellum.

Heterotomous Feldspar, *M.* Periklin, *Breit.*



346. *Primary form:* an oblique rhomboidal prism; P : M=93° 19′, P : T=114° 45′, M : T =120° 18′. Occurs only in twin crystals similar to the annexed fig., in which composition is of *the first kind*, parallel to M. *Cleavage* perfect, parallel to P and T; rather more easily obtained in the direction of T, instead of P, and in this respect unlike feldspar and albite.

H.=6. G.=2·54—2·55. *Lustre* pearly, sometimes vitreous upon P and T. *Streak* white. *Color* white, yellowish, or reddish. Subtransparent—subtranslucent; often the latter.

It contains, according to Prof. Gmelin's analyses of the Zöblitz variety, Silica 67·91, Alumina 18·93, Soda 9·99, Potash 2·41, Lime 0·15, Oxyd of Iron 0·48=99·87.

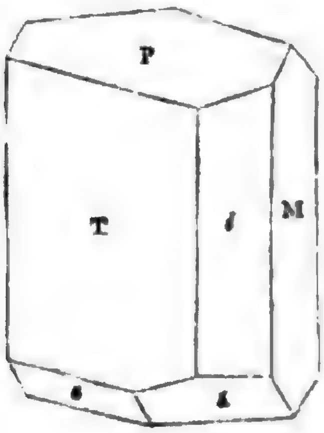
Obs. It is found in large and perfect crystals in sienite, at St. Gothard, in Switzerland; in the Pfunderstahl and Schmiernerthal, in the Tyrol; upon the Sau Alpe in Carinthia; at Zöblitz, in Bohemia, and elsewhere. It was distinguished from Albite by Breithaupt.

ALBITE. Spatum triclinatum.

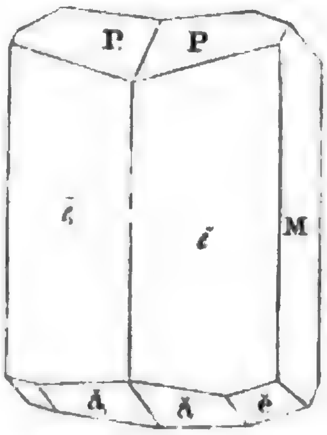
Tetarto-Prismatic Feldspar, *M.* Cleavelandite, *P.* and *Levy.* Kieselspath, *Haus*

347. *Primary form:* an oblique rhomboidal prism; P : M= 93° 50′, P : T=115° 5′, M : T=117° 53′. *Secondary forms:*

1.



2.



M : ē=119° 52′, P : ē=119° 51′, P : ă=127° 23′. *Cleavage* perfect, parallel with M and P, with T less so. *Compound crystals:* similar to the above figures; but usually flattened parallel to M, which face is consequently much enlarged;—this is an instance of composition similar to that described under pericline. *Imperfect crystallization:* lamellar and granular structure; the laminæ have sometimes a stellular arrangement; the particles of the granular structure are occasionally quite fine, approaching to impalpable.

H.=6. G.=2·6—2·68. The albite of Finbo, according to Eggertz, has a G. of 2·612; that of Broddbo, 2·619. *Lustre* pearly upon cleavage planes, vitreous in other directions. *Streak* white. *Color* white; also occasionally bluish, gray, reddish, greenish, and green; it sometimes exhibits a bluish opalescence. Transparent—subtranslucent. *Fracture* uneven. Brittle.

Its composition, according to Eggertz, (Afhandlingar, v. 28,) Rose, (Gilbert's Annalen, lxxiii. 173,) and Laurent and Holmes, (Ann. de Ch. et de Ph. vol. 60, p. 331,) is as follows:

	From Finbo.	From Arendal.	Var. Cleavelandite.
Silica	70·48	68·46	68·4
Alumina	18·45	18·30	20·8
Soda	10·50	9·27	10·5
Lime	0·55	0·68	0·2
Oxyd of Iron and Mang.	——=99·98, E.	0·28=97·99, R.	0·1=100, L. & H.

Before the blowpipe the action is similar to that of feldspar.

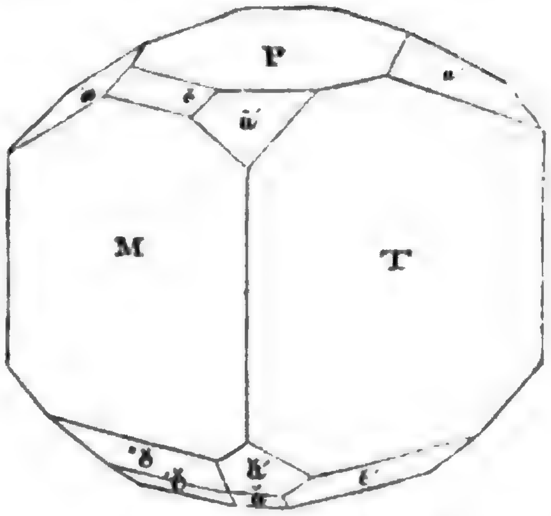
Obs. Albite often replaces feldspar as a constituent of granite; in other instances it is associated with feldspar, as in Pompey's pillar, and then may be generally distinguished by its superior whiteness. The albite granites are often repositories of several of the granite minerals, turmalines of different colors, beryls, &c. It is associated with pearl spar in the Tyrol, where it occurs in large transparent crystals; with epidote and garnet at Arendal; with eudialyte and hornblende in Greenland. It is frequently one of the constituents of sienite and greenstone. Such is the case in the rocks about Edinburgh. In Massachusetts, U. S., at Chesterfield, it occurs in lamellar masses, the laminæ arranged frequently so as to produce a wedge-like form, and having a slightly bluish tint. It is also met with at the same locality, of a finely granular structure, and rarely in small crystals. It is the bed of the fine red and blue tourmalines of Chesterfield. It occurs in a similar manner, and containing the same minerals, at Paris, Maine, and also at Goshen, Mass. At Haddam, Conn., it is accompanied with chrysoberyl, beryl, columbite, automalite, black turmalines, and pinite. At Monroe, Conn., is found a fine granular variety containing beryl.

The name *Albite*, is derived from *albus*, white, in allusion to its color, as observed by Gahn and Berzelius, who thus named it in 1814. The variety from Chesterfield was denominated Cleavelandite, in compliment to Prof. Cleaveland, by Mr. Brooke, who supposed at the time that it was a distinct species. The crystallization of albite was first perfectly developed by Dr. Gustavus Rose, in Gilbert's Annalen, Feb. 1823. More latterly, Mr. W. Phillips proved it to be a frequent constituent of the granite of England.

ANORTHITE. Spatum Vesuvianum.

Anorthomous Feldspar, ***M.*** **Christianite,** ***Monticelli.*** **Anorthite,** ***Rose.*** **Indianite,** ***H.***

348. *Primary form:* an oblique rhomboidal prism; P : T=110° 57′, M : T=120° 30′. *Secondary form:* T : ĕ (a plane replacing the



acute lateral edge)=94° 12′, P: ȧ=137° 32′, P : *a*′=133° 13′, P : ā′=138° 46′. *Cleavage* parallel with P and M perfect. *Compound crystals* of anorthite never occur in nature. *Imperfect crystallizations:* structure columnar, or coarse lamellar.

H.=6. G.=2·65—2·78; a massive variety was determined by Rose to have the specific gravity 2·762. *Lustre* of cleavage planes inclining to pearly; of other faces vitreous. *Streak* white. *Color* white. Transparent—translucent. *Fracture* conchoidal. Brittle.

It contains, according to G. Rose, (Gilbert's Annalen, lxxiii. 173,) Silica 44·49, Alumina 34·46, Lime 15·68, Magnesia 5·26, Peroxyd of Iron 0·74=100·63.

It is similar in its action before the blowpipe to the two preceding species, except that with carbonate of soda it does not afford a clear glass, but froths, and forms an enamel. It is entirely decomposed in concentrated muriatic acid.

Obs. Anorthite occurs at Mount Vesuvius, among the old lavas in the ravines of Monte Somma. It generally occupies the cavities of chloritic masses, and is associated with ice spar, augite, mica, and idocrase. It also occurs on the island of Procida, near the entrance to the bay of Naples.

Anorthite was first distinguished as a distinct species by Dr. G. Rose, in 1823, who named it from ανορθος, *oblique*, because all its interfacial angles were oblique. It was afterwards described by Monticelli, in his Mineralogia Vesuviana, and named Christianite, in honor of the crown prince of Denmark.

The species *Indianite*, agrees closely in composition and crystallization with anorthite. It is described as occurring in translucent grains of a greenish-white color, cleaving parallel to two planes, inclined to one another at an angle of 95° 15′. It consists, according to Chenevix and Laugier, of

Silica	42·5	43·0
Alumina	37·5	34·5
Lime	15·0	15·6
Oxyd of Iron	3·0	1·0
Soda	—=98, C.	2·6=96·7, L.

with a trace of manganese. It is infusible, but becomes friable and gelatinous in acids. It forms the gangue of the Indian corundum, and is found principally in the Carnatic, associated with garnet, fibrolite variety of kyanite, and hornblende.

LATROBITE. Spatum roseum.

Latrobite, *Brooke.* Diploite, *Breit.*

349. *Primary form:* an oblique rhomboidal prism; P : M=91° 9′, P : T=98° 30′, M : T=93° 30′; obtained from cleavage planes. *Cleavage* parallel to P, M, and T. Occurs also massive.

H.=5·5—6·5. G.=2·72, Gmelin; 2·8, Brooke. *Lustre* vitreous, of P dull, M and T unequally shining. *Color* a pale rose-red, or a pink, resembling the color of the lepidolite variety of mica. Subtranslucent—opaque.

Gmelin obtained the following composition in two analyses, (Annals of Phil. 2d ser., x. 235,)

Silica	44·653	41·780
Alumina	36·814	32·827
Lime	8·291	9·787
Oxyd of Manganese	3·160	5·767
Magnesia, with some Manganese	0·528	——
Potash	6·575	6·575
Water	2·041=102·062.	2·041=98·777.

Held in the platinum forceps in the blowpipe flame, it fuses with some intumescence into a white enamel. With borax, it affords a globule, which has a pale amethyst-red color in the oxydating flame, and is colorless in the reducing flame. With salt of phosphorus it melts into a clear glass, containing a skeleton of silica.

Obs. Latrobite has been found only on Ametik island, near the coast of Labrador, where it is associated with feldspar, mica, and calcareous spar. It was discovered by the Rev. C. J. Latrobe.

AMPHODELITE.

Nordenskiöld, in Jahresbericht, 1833, p. 174.

350. Resembles feldspar in crystalline form. *Cleavage* parallel to two planes, which meet at an angle of 94° 19′.

H.=4·5. G.=2·76. *Color* light red. *Fracture* similar to that of scapolite.

It contains, according to the analyses of Nordenskiöld, Silica 45·80, Alumina 33·45, Lime 10·15, Magnesia 5·05, Oxyd of Iron 1·70, Water 1·85=100.

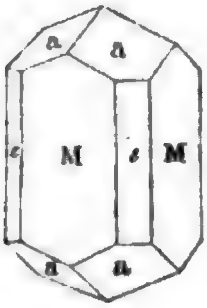
Obs. This species was found by Nordenskiöld in the limestone quarries of Lojo, in Finland.

SCAPOLITE. Spatum quadratum.

Pyramidal Feldspar, *M.* Meionite, Prismato-pyramidal Feldspar, *J.* Dipyre, *P.* Paranthine, Wernerite, *H.* Tetraklasit, *Haus.* Schmelzstein, Scapolith, *Wern.* Bergmannite?

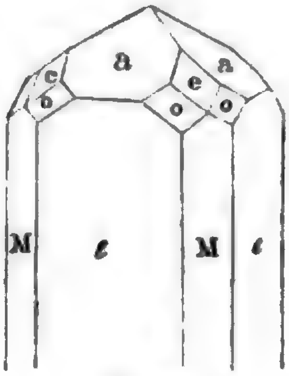
351. *Primary form:* a right square prism. *Secondary forms:*

1.



Gouverneur, N. Y.

2.



Vesuviu .

M : *e*=135°, *e* : a=121° 54′, a : a=136° 7′, a : e=158° 3½′. *Cleavage* parallel with M and *e* rather distinct, but interrupted. Imperfectly crystalline varieties occur columnar, lamellarly fibrous, and massive; commonly the particles are strongly coherent.

H.=5—5·5, nearly 6, a subtransparent variety from Gouverneur, N. Y. G.=2·612—2·749. *Lustre* often pearly externally, inclining to resinous; on the cleavage and fracture surface parallel with P, it is vitreous; on the lateral cleavage planes vitreous, inclining to resinous. *Streak* grayish-white. *Color* white, gray, blue, green, and red; colors usually light. Transparent—faintly subtranslucent. *Fracture* subconchoidal. Brittle.

It contains, according to Stromeyer, Nordenskiöld, John, and Vauquelin,

	Melonite, from Somma.	Scapolite, from Finland.	Wernerite.	Dipyre.
Silica	40·531	41·25	50·25	60
Alumina	32·726	33·58	30·00	24
Lime	21·245	20·36	10·45	10
Potash, with Soda	1·812	——	2·00	—
Perox. Iron	0·182	——	3·00	—
Protox. Mang.	——	0·54	——	—
Water	——=99·496, S.	3·32=99·05, N.	2·85=98·55, J.	2=96, V.

Strongly heated in the blowpipe flame it fuses into a vesicular glass, and intumesces considerably; it then assumes the appearance of ice, and continues no longer in fusion. With borax, it dissolves with effervescence and fuses into a clear globule.

Obs. The great variety of appearance among the different specimens of this species, gave rise to its division, by the earlier mineralogists, into several distinct species. *Meionite* includes the pure transparent perfect crystals found in the debris of Mount Somma. *Scapolite* was applied to the translucent varieties of a gray, greenish-gray, or green color. It sometimes occurs of a red tinge, from an admixture of iron. *Wernerite* occurs in short crystals, similar to the second of the above figures, and with darker shades of color than scapolite. *Paranthine* included the more compact varieties of a pure white and pale blue colors. *Dipyre* was distinguished from scapolite, principally, by its reddish-white color and thin columnar structure in imperfectly crystalline varieties. *Nuttallite* differs from Wernerite only in possessing a tinge of blue with the gray, and a feeble chatoyant reflection of light.

These several varieties of scapolite are usually met with in primitive regions; very often in the primitive limestone, near its junction with the granite; and in beds of magnetic iron, accompanying this rock. In the latter situation, scapolite occurs at Arendal, in Norway, and Wärmeland, in Sweden; also in fine crystallizations in Pargas, Finland, &c. At Arendal it is associated with hornblende and garnet in limestone, and occurs in long slender crystals. *Wernerite* is found in short thick crystals at the same locality. *Paranthine* occurs in the limestone quarries of Galsjo and Malsjo, in Wärmeland. *Dipyre* is confined principally to the torrent of Mauléon, in the western Pyrenees, where it is imbedded in slate.

Beautiful crystallizations of this species occur at Gouverneur, N. Y., thickly disseminated in primitive limestone, and associated with apatite, sphene, and augite. The crystals are usually thick and short prisms, varying in length from half to two inches, and presenting the form of the first of the above figures. In a similar gangue it is met with at Amity, N. Y., Bolton and Boxborough, Mass. *Nuttallite* also occurs at Bolton, in slender prisms seldom terminated; also at the same place a purple variety forming considerable masses, and having a distinctly cleavable structure. In Bucks Co., Penn., three miles west of Attleboro, in a quarry of primitive limestone, scapolite occurs both crystallized and massive, associated with tabular spar, pyroxene, zircon, apatite, and sphene. Compact varieties are met with near Marlboro', Vt., and Boxborough and Westfield, Mass. A pure white variety, somewhat fibrous in its structure, occurs at Monroe, Conn. The variety Bergmannite, which is frequently described as a distinct species, is stated to occur massive and in promiscuous concretions: *color* grayish, passing into white and brick-red; opaque; *lustre* pearly. It occurs at Stavern, in Norway, associated with feldspar, elæolite, and quartz.

GLAUCOLITE.

Bergmann, Edin. New Phil. Jour. III. 385.

352. Massive; traces of cleavage parallel with the faces of a rhombic prism of about 143° 30′, according to Brooke.

H.=5. G.=2·72—2·9. *Lustre* vitreous. *Color* lavender blue, passing into green. Subtranslucent. *Fracture* splintery.

It contains, according to Bergmann,

Silica	50·58	54·58
Alumina	27·60	29·77
Lime	10·27	11·08
Magnesia	3·73	——
Potash	1·27	4·57
Soda	2·96=96·41.	——=100,

with a little iron and manganese. Before the blowpipe it whitens and fuses only on the edges; with borax or salt of phosphorus, it is readily soluble.

Obs. This species was observed by Menge near Lake Baikal, in Siberia, imbedded in compact feldspar and granular limestone. It has also been met with at Lauvig, in Norway, accompanying elæolite.

GEHLENITE. Spatum Gehlenianum.

Stylobite.

353. *Primary form:* a right square prism, which is the usual form it presents. *Cleavage* parallel to P indistinct.

H.=5·5—6. G.=2·9166—3.029. *Lustre* resinous, inclining to vitreous. *Streak* white—grayish-white. *Color* different shades of gray; none bright. Faintly subtranslucent—opaque. *Fracture* uneven—splintery.

It contains, according to Fuchs, (Schweig. Journ. xv. 377,) Kobell, and Thomson,

Silica	29·64	31·0	29·132
Alumina	24·80	21·4	25·048
Lime	35·30	37·4	37·380
Protox. Iron	6·56	4·4	4·350
Water	3·30	2·0	4·540
Magnesia	——=99·6, F.	3·4=99·6, K.	——=100·45, T.

Before the blowpipe thin splinters fuse with difficulty. With borax it fuses slowly, forming a vitreous globule colored by iron. It gelatinizes in muriatic acid.

Obs. Gehlenite is found mostly at Mount Monzoni, in the Fassa Valley, in isolated or aggregated crystals, invested by calcareous spar. It also occurs massive in the same neighborhood, forming an exceedingly tough rock, containing imbedded crystals of pleonaste. According to Monticelli, this species is found indistinctly crystallized in calcareous spar at Vesuvius. Gehlenite was named by Fuchs in honor of his colleague, Gehlen.

GISMONDINE. Spatum volcanicum.

Abrazite. Zeagonite. Gismondine, *Leonhard*. Sesquisilicate of Lime, *Thom.*

354. *Primary form:* a right square prism. *Secondary form:*

a square octahedron, with truncated basal edges; e : e=122° 54′, M : e=132° 31′. *Cleavage* parallel with M imperfect.

H.=6—6·5. G.=2·16—2·2. *Lustre* adamantine. *Color* pale smalt-blue, milk-white, pearl-gray, rose-red. Translucent—nearly transparent. *Fracture* conchoidal.

It consists of Silica 41·4, Lime 48·6, Alumina 2·5, Magnesia 1·5, Oxyd of Iron 2·5=96·5, Carpi. It phosphoresces before the blowpipe and becomes friable, but does not fuse. It forms a jelly with acids without effervescence.

Obs. It occurs in white translucent crystals coating cavities of lava at Capo di Bove, near Rome; and in small purple colored crystals in the drusy cavities of ice spar and other volcanic minerals, at Vesuvius. The purple variety has been called zeagonite; but it appears to be identical with Gismondine. The white variety was first described by Gismondi, and hence its name.

MELLILITE.

355. *Primary form:* a right square prism. *Secondary form:* the primary with the lateral edges truncated.

Gives sparks with steel. G.=3·041—3·28. *Lustre* vitreous. *Color* yellow, reddish, or greenish. Opaque. *Fracture* subconchoidal.

It contains, according to Carpi, Silica 38, Lime 19·6, Magnesia 19·4, Alumina 2·9, Oxyd of Iron 12·1, Titanic Acid 4, Oxyd of Manganese 2=98.

It fuses before the blowpipe into a greenish glass. When pulverized it gelatinizes with acids.

Obs. It occurs in the cavities of a volcanic rock, at Capo di Bove and Tivoli, near Rome, associated with nepheline.

MANGANESE SPAR. Spatinius decolorans.

Bisilicate of Manganese. *Thomson.*

356. *Primary form:* an oblique rhomboidal prism; fig. 104, Pl. II.; M : T=121°, M : P=93°—94°, P : T=112° 30′. *Cleavage* highly perfect parallel with P; less perfect parallel with M and T.

H.=5·5—6·5. Some varieties have a hardness equal to 7. G.=3·4—3·634. *Lustre* vitreous. *Streak white.* *Color* light brownish-red, flesh-red, sometimes greenish, or yellowish, when impure. Transparent—opaque. *Fracture* conchoidal—uneven. Brittle.

The composition of the manganese spar from Longbanshyttan, Sweden, has been determined as follows, by Berzelius:

Oxyd of Manganese	52·60
Silica	39·60
Oxyd of Iron	4·60
Lime and Magnesia	1·50
Water	2·75=101·05.

The impure varieties, *Rhodonite*, *Photizite*, and *Allagite*, contain variable proportions of spathic iron, or carbonate of manganese, and alumine.

Dr. Thomson has made distinct species of two silicates of manganese from Franklin, New Jersey, which do not agree with the variety of long standing in mineralogy, in their composition.

One which he calls chemically the simple silicate of manganese, is composed of

Silica	29·64
Protox. Manganese	66·60
Peroxyd of Iron	0·92
Moisture	2·70
Alumina	trace=99·86.

Its color is a light brownish-red. Hardness 6·25. Sp. Gr. 4·078. Powder light red.

The other, a sesquisilicate, is composed of

Silica	42·70
Protox. Manganese	50·72
Protox. Iron	6·76=100·18.

It occurs in crystals whose primary is the oblique rhomboidal prism, which has been given above as the form of these species. The crystals are often several inches long, and an inch in diameter. H.=6·25. G.=3·586. *Color* brown, slightly reddish. It has been named Fowlerite, in compliment to Professor Fowler.

Before the blowpipe manganese spar becomes dark brown, and melts into a reddish-brown glassy globule. In the oxydating flame it colors borax hyacinth-red, but in the reducing flame, the borax remains uncolored. In the state of a powder, it is partly dissolved by muriatic acid, and the insoluble part becomes of a white color. All the varieties grow dark on exposure to the air, and often the weathered surface has nearly a black color.

Obs. The foreign variety first recognised as the foundation of this species, occurs at Longbanshyttan, near Phillipstadt, in Sweden, in iron ore beds, sometimes in broad foliæ, at others granular, and of a paler color; also at Elbingerode, in the Hartz; in the district of Ekatherinenburg, in Siberia; with gray copper ore, at Kapnik, in Transylvania.

The same variety occurs in the United States, in large boulders, at Cummington, Mass., scattered over the fields.

The variety Fowlerite is found at Hamburgh, N. J., at the Franklin furnace, where it occurs in a bed in limestone, with magnetic iron, Franklinite, and garnet. The silicate of manganese is associated with Troostite, automolite, and red zinc ore, at Sterling, N. J.; also at Cumberland, R. I., where it is associated with Yenite.

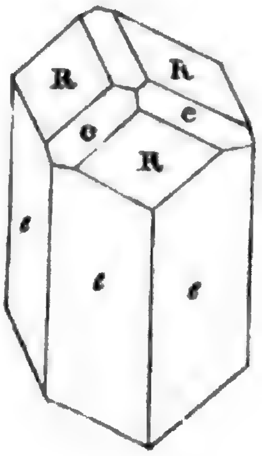
The varieties allagite, rhodonite, photizite, and corneous manganese, are found near Rübeland, in the Hartz.

Manganese spar receives a high polish, and is sometimes employed for inlaid work.

TROOSTITE. Spatinius rhombohedrus.

Ferruginous Silicate of Manganese, *Thomson*.

357. *Primary form:* an obtuse rhombohedron; R : R=115°, measured with the common goniometer. *Secondary form:* R : e=147° 30′, R : *e*=122° 30′. *Cleavage* perfect parallel to *e*, less distinct at right angles with the axis. Parallel to R in traces. Occurs also massive, and having a granular composition.



H.=5·5. G.=3·014—3·034, Thomson. *Lustre* vitreous, inclining to resinous. *Streak* white. *Color* pale asparagus-green, yellow, gray, reddish-brown; none bright. Transparent—translucent. *Fracture* conchoidal. Brittle.

According to Dr. Thomson, it consists of

Silica	30·650
Protox. Manganese	46·215
Perox. Iron	15·450
Moisture and Carbonic Acid	7·300=99·615.

In the blowpipe flame it becomes transparent, and fuses on the edges. To borax it gives the violet tinge of manganese. It dissolves with effervescence in muriatic acid, giving out chlorine.

Obs. Troostite occurs with Franklinite at Sterling, N. J., in beds of primitive limestone.

BUSTAMITE. Spatinius reniformis.

358. Occurs in spherical or reniform masses, having a radiated or almost laminated structure.

H.=6—6·5. G.=3·1—3·3. *Color* pale gray, with a slight tint of green or red. Subtranslucent.

Its composition, according to Dumas, (Ann. des Mines, 2d series, i. 272,) is as follows:

Silica	48·90
Protox. of Manganese	36·06
Lime	14·57
Protox. of Iron	0·81=100·34.

Obs. This mineral was discovered by M. Bustamente, of Mexico, accompanied with quartz and manganese, at Real de Minas de Fetela, and at Inotlœ, in the province of Publa, Mexico.

TABULAR SPAR. Augitus tabularis.

Prismatic Augite-Spar, *M.* Tabular Spar. Table Spar. Grammite. Schaalstein, *W.* Tafelspath, *M.*

359. *Primary form:* according to Brooke, an oblique rhomboidal prism; P : M=126° ? P : T=93° 40′, M : T=95° 15′. *Cleavage* perfect and easily obtained parallel to one of the lateral faces; less so parallel with the other; indistinct parallel with P. *Imperfect crystallizations:* columnar; particles long and slender; often sub-lamellarly arranged; at other times crossing, so as to produce reticulated forms; rather strongly coherent.

H.=4—5. G.=2·78—2·9 : 2·785—2·895, Thomson, specimens from the United States; 2·805, Haidinger, specimen from the Bannat. *Lustre* vitreous, inclining to pearly upon the faces of perfect cleavage. *Streak* white. *Color* white, inclining to gray, yellow, red, or brown. Subtransparent—translucent. *Fracture* uneven. Brittle.

It contains, according to Bonsdorf, Stromeyer, and Thomson,

Silica	52·58		51·445	51·716
Lime	44·45		47·412	42·352
Protox. Iron	1·13		0·401	1·908
Magnesia	0·68	Protox. Mang.	0·257	——
Water	0·99=99·73, B.		0·076=99·591, S.	3·200=100·176, T.

Before the blowpipe it fuses with difficulty into subtransparent colorless glass. With borax it forms readily a clear glass. Thrown into nitric acid, it effervesces rapidly at first, and soon falls to a powder.

Obs. Tabular spar is found in granite and primitive limestone; also in basalt and lavas.

It occurs in the copper mines of Cziklowa, in the Bannat of Temeswar. It accompanies garnet, fluor, and native silver, in limestone, at Pargas, in Finland, and Kongsberg, in Norway. At the Castle rock of Edinburgh it is met with in basalt, associated with Prehnite, presenting a fibrous radiated structure. A greenish-white variety occurs in lava at Capo di Bove, near Rome.

In the United States, this species occurs at Willsborough, N. Y., forming the sides of a powerful vein of garnet, which traverses a mountain of gneiss; at Boonville, N. Y., it is met with in large boulders; also at Grenville, Lower Canada, associated with green coccolite. It is found in large tabular masses of a fibrous structure, in Bucks Co., Penn., three miles west of Attleboro', associated with scapolite, pyroxene, and sphene.

Dr. Thomson has described under the name of *Wollastonite*, a variety of this species from Kilsyth, where it occurs in greenstone veins. It differs in composition from tabular spar in containing 1 part of trisilicate of soda to 4 of tabular spar.

SPODUMENE. AUGITUS RHOMBICUS.

Prismatic Triphane Spar, *M.* Prismatic Spodumene, *J.* Triphan, *L.* Triphane, *H.*

360. *Imperfect crystallizations:* structure foliated; yields by cleavage rhombic prisms of 93°.

H.=6·5. G.=3·11—3·19. 3·17, Haidinger; 3·188, Thomson; specimen from Dublin Bay. *Lustre* pearly. *Streak* white. *Color* grayish-green, passing into greenish-white and grayish-white. Translucent—subtranslucent. *Fracture* uneven.

It contains, according to Stromeyer and Thomson,

	Utön.	Killiney.
Silica	43·288	63·812
Alumina	28·776	28·508
Lithia	5·626	5·604
Protox. Iron	0·794	0·828
Protox. Mang.	0·204	Lime 0·728
Moisture	0·775=99·463, Strom.	0·360=99·840, Thom.

Before the blowpipe it loses its translucency and color, and swells to a foliated reddish-yellow mass, which easily falls to a powder. The exterior portions fuse into small glassy globules.

Obs. It occurs on the Island of Utön, in Sudermanland, Sweden, with magnetic iron ore, quartz, turmaline, and feldspar; also near Sterzing, in the Tyrol; and of a pale green or yellowish color, imbedded in granite, at Killiney Bay, near Dublin.

It occurs in granite, at Goshen, Mass., associated at one locality with blue turmaline and beryl; also at Chesterfield and Sterling, Mass. Spodumene is derived from σποδος, *ashes*, and was so called because it assumes a form like ashes before the blowpipe.

PYROXENE. AUGITUS DIATOMUS.

Paratomous Augite-Spar, *M.* Pyramido-Prismatic Augite, *J.* Augite. Coccolite. Diopside. Sahlite. Pyrgom. Fassaite. Pentaclasite. Jeffersonite,* *Keating.* Asbestus, in part. Green Diallage, Kokkolit, Baikalit, Omphazit, *W.* Pentaklasit, *Haus.* Pyroxene, Malacolithe, *Hauy.*

361. *Primary form:* an oblique rhombic prism; M : M=87° 5′,

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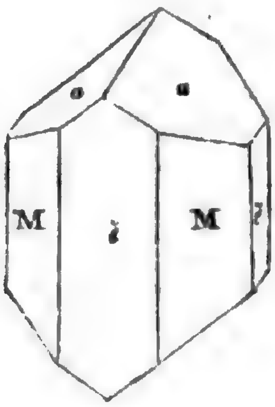
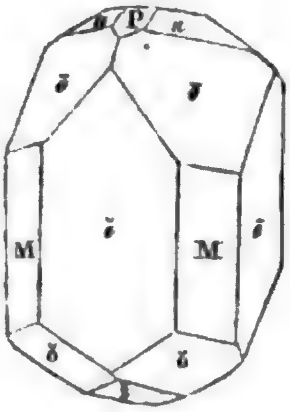
* For remarks on the identity of Jeffersonite and pyroxene, see an article by Dr. Troost, on the pyroxene of the United States, in the Jour. Acad. Nat. Sci. Philad. iii. 105; also by its original describers in vol. iv. of the same Journal, p. 3.

P : M=101° 5′. *Secondary forms:* fig. 1, a crystal from Etna, also Gouverneur, N. Y.; fig. 2, a crystal from Fassa, Tyrol; fig. 3, from Ala, Piedmont, and Bytown in Lower Canada.

1.



2.



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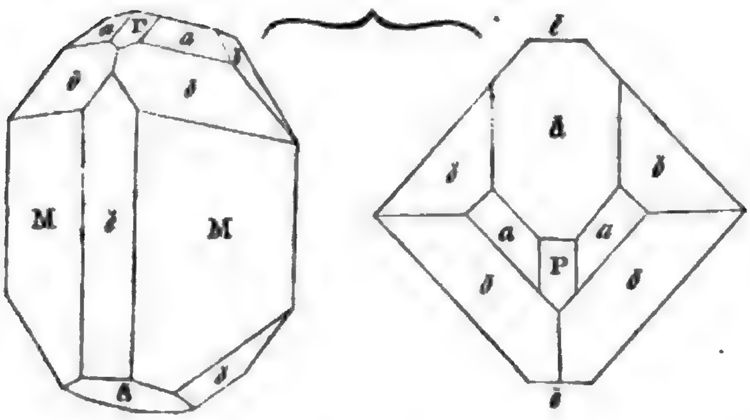


P : a=150°, a : a=120°, $\bar{o}:\bar{o}$=95° 28′, $\breve{o}:\breve{o}$ (adjacent planes) = 81° 46′, ŏ : ŏ=131° 8′, M : $\bar{e}$=136° 28′, M : $\breve{e}$=133° 33′. *Cleavage* parallel to M rather perfect, often interrupted; also parallel to $\breve{e}$ and $\bar{e}$. *Compound crystals:* fig. 14, Pl. III.; composition of the second kind; parallel to the front lateral edge. *Imperfect crystallizations:* coarse lamellar structure in large masses, parallel to P or $\breve{e}$, arising from an aggregation of separate individuals; the plane of union between the laminæ are joints of composition; granular—particles frequently very coarse and weakly connected; at other times fine and strongly coherent.

H.=5—6. G.=3·233—3·349. *Lustre* vitreous, inclining to resinous; sometimes pearly. *Streak* white—gray. *Color* green of various shades, verging on the one side to white or grayish white, and on the other, to brown and black. Transparent—opaque. *Fracture* conchoidal—uneven. Brittle.

This species presents a great variety of forms and is, therefore, subdivided into several varieties. These varieties in appearance, arise from the isomorphous nature of oxyd of iron and magnesia, on which account, one may replace the other without producing a change in the crystalline form. Pyroxene invariably contains one of these two substances, and according as the iron or the magnesia is more abundant the color varies, becoming darker as the iron predominates. The following two tables exhibit the composition of the *light* and *dark* varieties.

1. Light varieties, according to Rose, Bonsdorf, and Hisinger:—

	Wärmeland.	Taumare.	Var. Sahlite.
Silica	55·32	54·83	54·18
Lime	27·01	24·76	22·72
Magnesia	16·99	18·55	17·81
Prot. of Mang.	1·59	——	1·45
Perox. Iron	2·16	0·99	2·16
Alumina	——	0·28	——
Water	——=103·07, R.	0·32=99·73, B.	1·20=99·52, H.

Before the blowpipe they fuse, *per se*, into a colorless glass. With borax or soda, they easily melt into a transparent glass; with salt of phosphorus, they undergo a slow decomposition, and leave a siliceous residue.

2. Dark varieties, according to Rose:—

	Dalecarlia.	Dalecarlia.	Wärmeland.
Silica	54·08	54·55	53·36
Lime	23·47	20·21	22·19
Magnesia	11·49	15·25	4·99
Protox. of Iron	10·02	8·14	17·38
Protox. of Mang.	0·61	0·73	0·09
Alumina	——=99·67.	0·14=99·02.	——=98·01.

Their action before the blowpipe is similar to the preceding, except that the color of the bead is affected by the presence of the iron.

Obs. The term *augite* is often applied to this species, but was formerly restricted to opaque individuals of a dark green color, sometimes inclining to brown or black; it is often a volcanic product. The *crystallized green earth* found in beds of trap tufa, are the result of the decomposition of augite. *Diopside* presents dark green, and greenish-white colors, and is often subtransparent; it occurs in compressed divergent prisms, and in crystalline masses, having a coarse foliated structure, arising from composition parallel with P. The name *Alalite* has been applied to specimens of this variety from Ala, in Piedmont. *Sahlite* includes subtranslucent imperfectly crystallized specimens of a pale green, or grayish-green color. *Baikalite*, *pyrgom*, *Fassaite*, are names of dingy green varieties of Sahlite. *Omphazite* is a compact foliated leek-green variety. *Coccolite* (from *κοκκός, a seed*) includes granular varieties; the particles may be of various sizes, and are generally angular and easily separable. Occasionally they appear rounded. Green diallage, a grass-green variety, occurs either massive or crystallized; the massive specimens have a granular or foliated structure, the latter arising from composition parallel with P or ĕ. The above varieties are separated by very slight shades of difference, and, in general, the distinctions are quite unimportant.

Pyroxene is principally confined to primitive basaltic or volcanic rocks, and is associated at different localities with granite, granular limestone, serpentine, greenstone, basalt, or lavas. Aussig and Teplitz, in Bohemia, afford large crystals of augite imbedded in basalt. It also occurs in small but highly polished crystals in the lavas of Vesuvius, accompanied with nepheline, idocrase, and mica. Diopside is met with in crystals at Ala, in Piedmont, associated with garnets and talc in veins traversing serpentine. Its more transparent crystals from this locality are sometimes polished and worn as gems. Coccolite occurs in veins in primitive rocks at Arendal, in Norway. Sahlite is met with in a similar situation at Sahla, and elsewhere. Baikalite occurs principally on the borders of Lake Baikal, at the mouth of the Sljumanka River. Omphazite accompanies granular garnet at the Sau Alp, in Carinthia, and near Hoff, in Bayreuth, with the smaragdite variety of hornblende, which it much resembles.

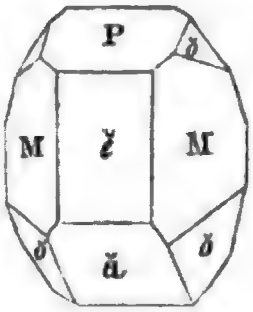
Beautiful white subtransparent crystals of this species are met with at Bytown, Lower Canada, where they occur, often one and a half inches long and an inch in diameter, in calcareous spar. Crystals, equally large but less clear, are found in the town of Canaan, Conn., disseminated in beds of Dolomite; also at Kingsbridge, N. Y., with white hornblende. Black crystals occur in the trap at Montreal. Diopside is found in handsome crystals in the limestone quarry of Bolton, Mass. Sahlite occurs in the verd-antique quarries of New Haven and Milford, Conn.; in the iron mine at Monroe, N. Y.; at Bolton, Mass. Coccolite of a fine green color is met with at Willsborough, N. Y., in a granite vein containing garnet and tabular spar. In a similar situation, both crystalline and granular varieties are found in Bucks Co., Penn., three miles west of Attleboro'; also in large boulders at Boonville, N. Y. Near Ticonderoga, at Rogers' Rock, on Lake George, an imperfectly crystalline pyroxene is very abundant; also at Monroe, N. Y.

Pyroxene was thus named by Haüy, from πῦρ, *fire*, and ξένος, *stranger*, in allusion to its occurrence in lavas, where, according to Haüy, it did not naturally belong, or was a stranger. *Augite*, which is frequently employed to designate this species, is derived from αὐγη, *lustre*, alluding to the fact, that its lustre is usually superior to that of hornblende.

Crystals of this species have been obtained by fusion, and are not unfrequent, of a black color, among the iron slags of Sweden. Mitscherlich and Beudant have succeeded in forming white crystals, by mingling silica, lime, and magnesia, and subjecting them in a charcoal crucible to the heat of a porcelain furnace.

BUCKLANDITE. Augitus dystomus.

Dystomic Augite-Spar, *Haid.* Diagonal Scotine, *Breit.*



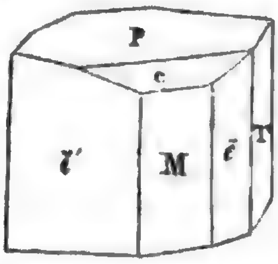
362. *Primary form:* an oblique rhombic prism; M : M=70° 40′, P : M=76° 4′, or 103° 56′. *Secondary form:* P:M=103° 56′, M : ĕ=125° 20′, P : ĕ=114° 55′, P : ă=99° 41′, ĕ : ă=164° 46′. *Cleavage* not observable.

H. 6 or higher. *Lustre* vitreous. *Color* dark brown, nearly black. Opaque. *Fracture* uneven.

Obs. Its crystals are usually small; rarely they occur an inch or more in length. It is met with at Arendal, in Norway, where it is accompanied by black hornblende, feldspar, and apatite. It has also been observed by Prof. G. Rose, in minute but brilliant crystals in the lavas of the Lacher-See. According to Rose, it is completely soluble in muriatic acid; he obtained a specific gravity of 3.945. This species was instituted by Levy. It bears a strong resemblance to pyroxene.

BABINGTONITE. Augitus acrotomus.

Axotomous Augite-Spar, *M. Levy*, Ann. Phil. 2d ser. VII. 275.



363. *Primary form:* an oblique rhomboidal prism; P : M=92° 34′, P : T=88°, M : T=112° 30′, P : *a*=150° 25′, M : ē=137° 5′, M : ĕ=132° 15′, ē : ĕ=89° 20′, Levy. *Cleavage* perfect, and easily obtained parallel with P, less perfect in the direction of T.

H.=5·5—6. G.=3·4—3·5. *Lustre* vitreous, splendent. *Color* dark greenish-black; thin splinters green perpendicular to P, and brown parallel to the same; faintly translucent. Large crystals, opaque, or faintly subtranslucent. *Fracture* imperfectly conchoidal.

It contains, according to Mr. Children, Silica, Iron, Manganese, Lime, and a trace of Titanium. Before the blowpipe it fuses on the surface into a black enamel. With borax it affords a clear amethystine colored globule, which becomes green in the reducing flame.

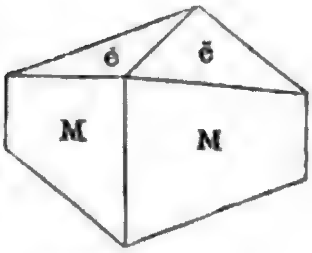
Obs. Babingtonite occurs in distinct crystals at Arendal, in Norway, associated with epidote and massive garnet, and in the Shetland Isles, imbedded in white quartz. It was named in compliment to Dr. Babington, by Mr. Levy, who first distinguished it as a species; it resembles some dark varieties of pyroxene.

HORNBLENDE. Augitus Protæus.

Hemi-Prismatic Augite-Spar, *M.* Axotomous Shiller-Spar or Green Diallage, Hemi-Prismatic Augite, *J.* Actinolite, Tremolite, Pargasite, Smaragdite, Asbestus, in part, Amianthus, Amianthinite, Amianthoid, Lotalite, Amphibole, Actinote, Strahlstein, Tremolith, Kalamit, Amiant, *W.* Grammatit, Byssolith, *Haus.*

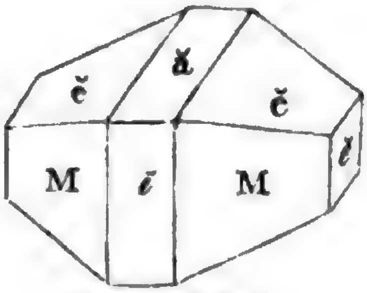
364. *Primary form :* an oblique rhombic prism ; M : M=124° 30′, P : M=103° 13′. *Secondary forms :*

1.



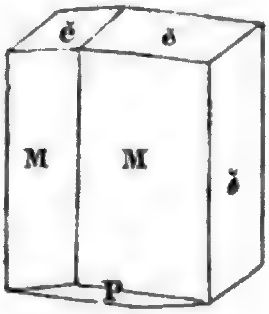
Edenville, N. Y.

2.



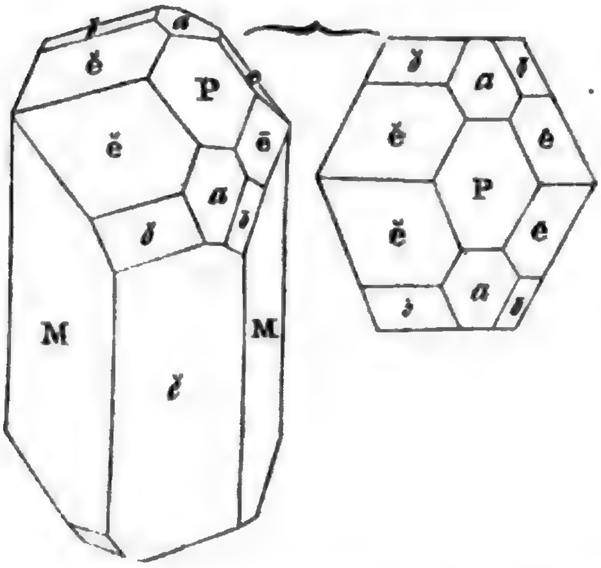
Gouverneur, N. Y.

3.

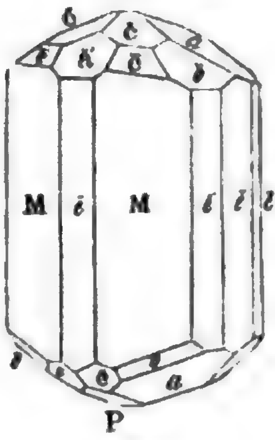


Teplitz, Bohemia.

4.



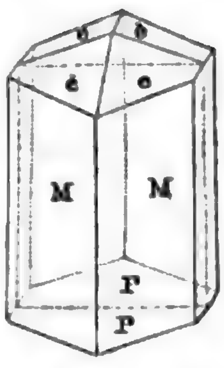
5.



Vesuvius.

ĕ : ĕ=149° 38′, ă : ĕ=164° 49′, ă : ē=104° 58′, M : ē=152° 15′, M : ĕ=117° 45′. *Cleavage* highly perfect, parallel with M. Sometimes distinct parallel to the diagonals. Lateral planes often longitudinally striated.

6.



Compound crystals: composition of *the second kind*, parallel to the obtuse edge M : M. The simple crystals composing this twin, are represented in fig. 3. *Imperfect crystallizations:* fibrous, and slightly divergent columnar; columns coarse—filiform—sometimes lamellar, often exceedingly delicate fibres: granular; particles of various sizes usually strongly coherent; sometimes friable.

H.=5—6. G.=2·9—3·2; 2·931, tremolite variety; 3·026, actinolite, from Zillerthal; 3·167, basaltic hornblende, from Lower Stiria. *Lustre* intermediate, between vitreous and pearly on cleavage faces; occasionally true pearly; vitreous parallel to P. Some fibrous varieties have a silky lustre. *Streak* white, grayish-white, brown. *Color* various shades of green, inclining to blackish-green and a pure black on the one side, and white on the other. Occasionally, almost transparent; usually, subtranslucent—opaque. *Fracture* subconchoidal, uneven. Brittle.

Few minerals, if any, present a greater diversity of appearance than hornblende. It was, therefore, in the earlier state of the science, distributed into several species, which crystallographic considerations have now shown to be varieties of the same species.

Hornblende includes the dark green, blackish green, and black individuals of the species. *Pargasite*, or *Pargas hornblende*, is applied to green (rather dark) colored crystals of hornblende, having high degrees of lustre. *Actinolite* generally presents lighter green colors, and is usually crystallized in long slender prisms. When in distinct crystals, and with high degrees of lustre, it is termed *glassy* actinolite; if columnar in its structure, *asbestiform* actinolite; if granular, *granular* actinolite. The individuals having a white color, were named *tremolite*, except when the particles were very thin columnar or filiform, in which case it was designated *asbestus*; and the more delicate specimens of asbestus, possessing a silky lustre, were distinguished by the name *amianthus*. *Rock cork* and *mountain leather* are white varieties, composed of minute fibrous particles interlacing one another, and forming a mass that will float on water. *Green diallage* is a mixture of thin laminæ of hornblende and pyroxene.

The different varieties of hornblende differ somewhat in their constitution. The following are a few of the analyses by Bonsdorf, (Kong. Vet. Acad. Handl. 1821:)

	Var. Tremolite.		Glassy Actinolite.	Pargasite.	Var. Hornblende.	
Silica	60·31	60·10	59·75	46·26	43·83	45·69
Magnesia	24·23	24·31	21·10	19·03	13·61	18·79
Lime	13·66	12·73	14·25	13·96	10·16	13·83
Alumina	0·26	0·42	——	11·48	7·48	12·18
Protoxyd of Iron	0·15	1·00	3·95	3·48	18·75	7·32
Protoxyd of Mang.	—	0·47	0·31	0·36	1·15	0·23
Hydrofluoric Acid	0·94	0·83	0·76	1·60	0·41	1·50
Water	0·10	0·15	—	0·61	0·50	—
	99·65	100·01	100·12	96·78	100·89	99·53

Before the blowpipe it readily enters into fusion, attended with a slight ebullition. The *white* varieties form a subtransparent glass; the *green*, a glass, colored more or less by the iron they contain. With borax it fuses easily, producing a similar globule. It is not decomposed with salt of phosphorus; after a long blast, the glass (of white varieties) becomes opaline on cooling. With a very small portion of carbonate of soda, it fuses into a transparent, or colored glass, as above. More of the flux causes an intumescence, and the formation of an infusible scoria.

Obs. The variety hornblende of this species is one of the constituents of sienite and greenstone. It also forms beds in primitive regions. Frequently it possesses a slaty structure, and is then called hornblende-slate. Hornblende also occurs in primitive limestone. Actinolite is found in the greatest perfection in talcose rocks, and tremolite occurs most abundantly in the primitive limestones and dolomite. Asbestus often traverses serpentine rocks and primitive limestones.

Aussig and Toplitz, in Bohemia; Tunaberg, in Sweden; Pargas, in Finland; afford fine specimens of the dark colored hornblendes. Actinolite occurs at Saltzburg and Greiner, in the Zillerthal; Tremolite, at St. Gothard, in primitive limestones or dolomite; also at Sebes in Transylvania, the Tyrol, the Bannat, Gulsjo in Sweden, Glentilt, &c. A soft asparagus-green variety occurs at Normarken, in Sweden, in prisms in serpentine; it has been called *calamite.* Asbestus is found in Savoy, Saltzburg, the Tyrol; also in the island of Corsica, where it is so abundant that Dolomieu employed it in packing his minerals. Rock cork is obtained in Saxony, Portsoy, and Leadhills, where also mountain leather occurs. Oisans, in France, affords a variety of amianthus, composed of fibres having some degree of elasticity. It is the *amianthoide*, of Haüy.

In the United States, hornblende occurs in shining black crystals, with truncated acute lateral edges, at Franconia, N. H. Also with the obtuse edges truncated, at the same place, and at Chester, Mass.; and with distinct terminal secondary planes, at Newton, N. J. Small, but perfect crystals, of a black color, are met with at Willsborough, N. Y., where they occur on a mountain near the locality of tabular spar and garnet, imbedded in black turmaline. Fine crystallizations, of a dark green color, have been obtained at Gouverneur, St. Lawrence Co., N. Y., where it is associated with apatite, pyroxene, and crystallized feldspar; the crystals are sometimes two, or even three inches in diameter, though possessed of a length of little more than an inch. Other slender crystals, (var. Pargasite,) of high degrees of lustre, occur in the same region, and at Antwerp, N. Y. Amity, N. Y., affords distinct reddish-brown crystals, one or two inches long, and nearly the same in diameter. The limestone of Edenville, N. Y., contains highly polished crystals of a hair-brown and greenish-white color. Beautiful specimens of glassy actinolite, are to be obtained in the steatite quarries of Windham, Readsborough, and New Fane, Vt., also at Middlefield, Mass. New Fane affords also a friable granular variety, composed of intermingled grains of actinolite and quartz, also asbestiform and massive specimens. At Plympton, Vt., and at Edenville, N. Y., are obtained massive and easily cleavable varieties of hornblende. Tremolite, or white hornblende, occurs abundantly in large flattened crystals, often above an inch long, and three quarters of an inch wide, at Canaan, and other places in Litchfield Co., Conn., imbedded in dolomite beds. Less splendid specimens, though interesting, are common throughout the dolomite beds and granular limestone of the country. It occurs also near Philadelphia, at London grove, in a limestone quarry. Asbestus is found abundantly on Staten Island, N. Y.; at West Farms, Conn.; at Brighton and Dedham, Mass.; at Barnet's Mill, Fauquier Co., Va.

A variety of hornblende, on the island of Corsica, admits of a high polish, and is known to the Italian lapidaries under the name of *Verde de Corsica duro.* Asbestus was manufactured into cloth by the ancients, who were acquainted with its incombustibility. This cloth was often the material for their napkins, and was preferred for this purpose on account of the ease with which it was cleansed; it was merely necessary to throw them into the fire. This material was also employed for the wicks of lamps in the ancient temples, and because it maintained a perpetual flame without being consumed, was named *ασβεστος*, *unextinguished.* It is used at the present time, for the same purpose, by the natives of Greenland. The ancients also called it *αμιαντος*, *undefiled*, because of the simplicity of the means of restoring it, when soiled, to its original purity.

Hornblende was thus named in allusion to its extreme toughness; in this respect slightly resembling horn. The radiating, or divergent structure, frequently presented by actinolite, suggested this name from *ακτῖν*, *radius solis.* Tremolite was first found at Tremola, in Switzerland, and Pargasite, at Pargas, in Finland.

ANTHOPHYLLITE. Augitus phyllinus.

Prismatic Schiller-Spar, *M.* Strahliger Authophyllite, *W.* Strelite.

365. *Primary form:* a rhombic prism; M : M=about 125° 30′, and 54° 30′. *Cleavage* parallel to M and both diagonals; that parallel to the longer diagonal the most distinct.

H.=5—5·5. G.=2·94—3·1558. *Lustre* submetallic, inclining to pearly. *Streak* white. *Color* between gray and dark clove-brown; also brownish-green. Translucent–subtranslucent. Brittle.

It contains, according to Vopelius, (Pogg. Annalen, xxiii. 355,) Gmelin, (Pogg. Ann. xxiii. 358,) and Thomson, (Min. i. 207,)

Silica	56·74	56	57·12
Alumina	—	3	trace
Magnesia	24·35	23	25·92
Lime	—	2	1·32
Protox. Iron	13·94	13	13·52
Protox. Mang.	2·38	4	—
Water	1·67=99·08, V.	—=101, G.	1·36=99·24, T.

It is, therefore, composed of 3 parts of *bisilicate of magnesia* and 1 of *bisilicate of iron.*

Before the blowpipe, *per se*, it remains unaltered. With borax it melts with difficulty into a grass-green transparent bead.

Obs. Anthophyllite occurs in promiscuous fibres and foliated distinct concretions, in beds of mica slate, accompanied by garnet, pyroxene, turmaline, iolite, &c. The cobalt and copper mines of Kongsberg, and of Snarum, near Modum, in Norway, are among its foreign localities. It also occurs at Ujordlersoak, in Greenland, associated with pyroxene.

At Haddam, Conn., it is associated with turmaline and iolite, in mica slate. It is also found in the same rock with quartz, at Chesterfield and Blandford, Mass.

This mineral approaches hornblende very closely in external characters and composition. Its lateral interfacial angle has been stated at 124° 30′, which is identical with that of hornblende; but it was obtained from cleavage faces, and cannot be wholly relied on. The name *anthophyllite* is derived from ἄνθος, *flower*, and φύλλον, *leaf.*

CUMMINGTONITE. Augitus scopiformis.

366. *Imperfectly crystalline:* structure thin, columnar, divergent, scopiform, stellular, rather incoherent.

H.=6—6·5. G.=3·2014. *Lustre* somewhat silky. *Color* ash-gray. Translucent—opaque. Brittle.

According to Muir, it contains Silica 56·543, Protoxyd of Iron 1·669, Protoxyd of Manganese 7·802, Soda 8·439, Volatile Matter 3·178. Before the blowpipe, *per se*, it is infusible, except on thin edges. With carbonate of soda it fuses with effervescence into a dark glass. With borax it forms a black glass.

Obs. It occurs in mica slate, at Cummington and Plainfield, Mass., associated with garnet and iron pyrites.

ARFWEDSONITE. Augitus peritomus.

Peritomous Augite-Spar, *M.* Arfwedsonite, *Brooke.* Arfvedsonite.

367. *Primary form:* an obtuse oblique rhombic prism; M : M (cleavage planes) =123° 55′. *Cleavage* eminent and affording brilliant surfaces parallel to M; none parallel to the base. It is doubtful whether the prism be right or oblique.

H.=5—6. G.=3·35—3·369, Thomson. *Lustre* vitreous. *Color* black. Opaque.

It contains, according to Dr. Thomson, Silica 50·508, Peroxyd of Iron 35·144, Sesquoxyd of Manganese 8·92, Alumina 2·488, Lime 1·56, and Moisture 0·96=99·58. Before the blowpipe, in the platinum forceps, it fuses readily into a black globule. With borax it affords a glass colored with iron. With salt of phosphorus, a similar but paler globule is obtained; it becomes colorless on cooling, and leaves a skeleton of silica.

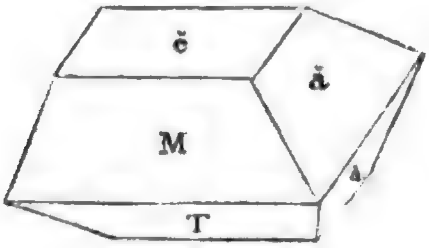
Obs. Arfwedsonite is associated with sodalite and eudialyte, at Kangedluarsuk, in Greenland. It was considered a ferriferous hornblende, until its distinctive characters were pointed out by Brooke, who named it in honor of Prof. Arfwedson.

EPIDOTE. Augitus rhomboideus.

Prismatoidal Augite-Spar, *M.* Zoisite. Pistacite. Thallite. Scorza. Delphinite. Arendalite. Piemontischer Braunstein, *W.*

368. *Primary form:* a right rhomboidal prism; M : T=115° 24′. *Secondary forms:*

1.



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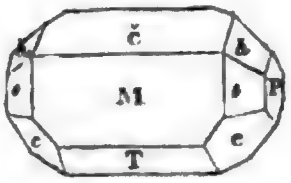

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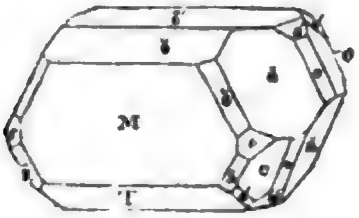


figs. 1 and 2, of a crystal from Arendal, Norway. M : ĕ′=116° 17′, T : ĕ′=128° 19′, ŏ : ŏ=109° 27′. ĕ′ : ŏ=125° 16′. M : *e*′=121° 34′, M : ĕ=90° 33′. T : e=144° 31′. *Cleavage* perfect parallel to M, less so to T. *Compound crystals:* composition of the *first kind* parallel to M. *Imperfect crystallizations:* structure columnar, divergent, or parallel; granular, particles of various sizes, sometimes impalpable.

H.=6—7. G.=3·25—3·46; 3·425, Haidinger; 3·46, Descotils; 3·289, Thomson, var. Scorza. *Lustre* vitreous, inclining to pearly upon M, both as faces of crystallization and cleavage. *Streak* grayish-white. *Color* green and gray prevalent; green colors usually somewhat yellowish. Crystals commonly less yellow in the direction of the vertical axis, than at right angles with it. The gray colors occasionally pass into red and white. Subtransparent —opaque; generally subtranslucent. *Fracture* uneven. Brittle.

Those specimens which were formerly separate, under the name of Zoisite, are included in this species, in consequence of the identity of their crystallization with the true epidote. They differ essentially, however, in composition, and also in color; Zoisite being usually of a gray, brownish, or bluish-gray, or white color, and epidote presenting some variety of green. Other less distinctly marked varieties are as follows: *Scorza*, a variety found in the form of a sand on the banks of the Arangos, and so named by the inhabitants of Transylvania; *Epidote magnésifère*, of Haüy, the *Piemontischer Braunstein*, of Werner, is a manganesian epidote; it contains sometimes twelve per cent. of oxyd of manganese, and, owing to its presence, has a reddish-black color.

The following table exhibits the composition of epidote and Zoisite, according to Laugier, Thomson, and Bucholz:

	Epidote.	Epidote.	Zoisite.	Zoisite.
Silica	37·200	38·240	40·25	39·300
Alumina	23·825	18·828	30·25	29·488
Lime	23·075	24·080	22·50	22·956
Magnesia	——	0·480	——	——
Protoxyd of iron	13·041	17·440	4·50	6·480
Moisture	2·000	0·800	2·00	1·360
	99·141, L.	99·868, T.	99·50, B.	99·584, T.

Epidote fuses with difficulty before the blowpipe, and only on the thinnest edges, into a transparent glass. With borax it intumesces, and ultimately affords a clear globule. Zoisite swells up and melts on the edges to a yellow glass; with borax it fuses into a diaphanous glass. If manganese is present in epidote, it tinges the flame an amethystine color.

OBS. Arendal, in Norway, affords magnificent crystallized specimens of this species, and has given the name *Arendalite* to the epidote of its localities. Large translucent crystals occur at Aggruvan, near Nordmark, in Sweden. Bourg d'Oisans is a fine locality of pistachio-green crystallized specimens. Zoisite occurs accompanying kyanite, hornblende, and titanium, in the Sau Alpe and the Bacher Mountain in Styria, in the Tyrol, &c. The manganesian variety occurs at St. Marcel, in the valley of Aosta, in Piedmont.

At Franconia, N. H., crystallized specimens of epidote are quite abundant. It also occurs in the same vicinity in a granular form, and of a pistachio-green color, containing imbedded dodecahedral crystals of magnetic iron. Crystals of epidote have also been found at Cumberland, R. I., in veins and cavities, in a kind of trap rock. Haddam affords small quantities of a similar variety, imbedded in gneiss. Zoisite is obtained in specimens, having a large columnar structure, at Milford, Conn., and at Willsborough, Vt.; also more abundantly at Goshen and Williamsburg, Mass., where it exists in quartz, traversing mica slate; at Montpelier, Vt., where it occurs of a bluish-gray color, associated with calcareous spar in mica slate. A variety occurs in the eastern part of Maine, which is purplish-red at the centres of the fibrous masses, but pistachio-green, where the columns are most divergent.

The name *Epidote* was derived by Haüy from *επιδιδωμι, to increase*, in allusion to the fact, that the base of the primary is frequently very much enlarged in some of the secondary forms. *Zoisite* was so named in compliment to its discoverer, Baron Von Zois.

WITHAMITE. Augitus Withami.

369. *Primary form:* a right rhomboidal prism; M : T=116° 40′, T : ĕ=128° 20′. *Secondary form:* similar to fig. 1, under epidote.

H.=6. G.=3·1—3·3. *Lustre* vitreous. *Streak* white. *Color* carmine-red, or pale straw-yellow, when seen in certain directions by transmitted light. Translucent.

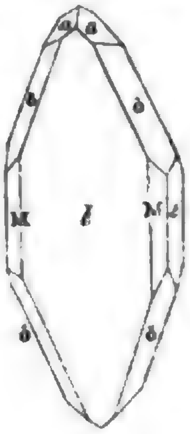
In an imperfect analysis, Dr. Coverdale obtained for its constitution, Silica 55·28, Alumina 16·74, Peroxyd of Iron 21·13, Lime 8·13, and Water 3·13=104·41. Its behavior before the blowpipe very much resembles that of epidote. It intumesces, and fuses with difficulty into a greenish-gray scoria. With salt of phosphorus it dissolves with effervescence into a globule, containing a skeleton of silica, and becomes opaque on cooling.

Obs. This mineral was discovered by Mr. Witham on the surface of a reddish trap in Glencoe, and was named and described by Dr. Brewster, (*Brewster's* Journ. II. 218.) It bears a close resemblance to epidote, and possibly is a variety of that species.

ACMITE. Augitus cuspidatus.

Achmite Akmit, *Haid.* *Stromeyer* and *Berzelius*, Kong. vet. Ac. Handl. 1821, p. 160.

370. *Primary form:* an acute oblique rhombic prism; M : M= 86° 56′. *Secondary form:* M : ĕ=133° 28′, M : ĕ= 136° 32′, *a* : *a*=119° 30′. *Cleavage* distinct parallel to M, less so parallel to the diagonals. Plane ĕ often longitudinally striated. *Compound crystals:* composition of the *second kind* parallel to ĕ. These forms are of common occurrence.



H.=5·5—6. G.=3·2—3·4; 3·398, Thomson. *Lustre* vitreous, inclining to resinous. *Streak* pale yellowish-gray. *Color* brownish or reddish-brown; in the fracture, blackish-green. Opaque. *Fracture* uneven—earthy. Brittle.

It contains, according to Berzelius (Kong. Vet. Acad. Handl. 1821, p. 160) and Lehunt, (Thomson's Min. i. 480,)

Silica	55·25		52·016
Perox. Iron	31·25	Protox.	28·080
Soda	10·40		13·333
Protox. Mang.	1·08		3·487
Lime	0·72		0·876
Magnesia	—		0·504
Alumina	— =98·70, B.		0·685=98·981, L.

Before the blowpipe it readily fuses into a black bead. It is not attacked by acids.

Obs. Acmite has been found only at Rundemyr, about four miles north of Dunserud, near Kongsberg, in Norway. It there occurs in crystals nearly a foot long, imbedded in granite and quartz. They are often macled and bent, and are detached with difficulty, on account of their frangibility.

The name of this species is derived from *ακμη*, *a point*, in allusion to the peculiar pointed form of the extremities of the crystals. It has been improperly spelled *achmite*.

AMBLYGONITE. Augitus Lithicus.

Amblygonic Augite-Spar, ***Haid.***

371. *Primary form:* a rhombic prism; but whether right or oblique is uncertain; M: M=106° 10′, and 73° 50′. Planes M usually rough. *Cleavage* parallel to M producing brilliant surfaces. Also massive, structure columnar.

H.=6. G.=3—3·04. *Lustre* vitreous, inclining to pearly on the faces of perfect cleavage. *Color* pale mountain, or sea-green. Subtransparent—translucent. *Fracture* uneven.

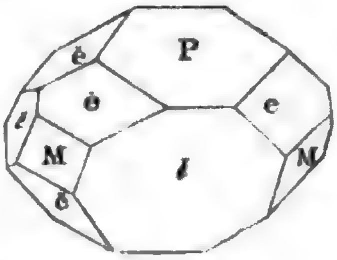
According to Berzelius, it contains 55·69 of Phosphoric Acid, 25·69 of Alumina, and 9·11 of Lithia. Before the blowpipe it fuses easily, with intumescence, and becomes opaque and white on cooling. With borax it forms a transparent colorless glass.

Obs. This species has hitherto been found only at Chursdorf, near Penig, in Saxony, where it is associated with turmaline and garnet in granite. It was first ranked as a species by Breithaupt. Its trivial name is derived from αμβλυς, *blunt*, and γωνια, *angle*.

TURNERITE.

Levy, **Ann. of Phil. XVIII. 241. Pictite.**

372. *Primary form:* an oblique rhombic prism; M : M=96° 10′, P : M=99° 40′. *Secondary form:* M : ê=138° 5′, M : ĕ= 131° 55′, P : ē=133° 50′. *Cleavage* parallel with both diagonals of the prism, one more perfect than the other. H. above 4. *Lustre* adamantine. *Streak* white or grayish. *Color* yellow or brown. Transparent—translucent.



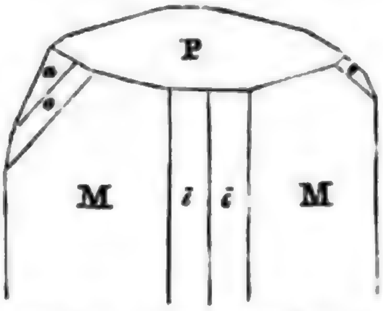
According to Children, it contains Alumina, Lime, Magnesia, and a little Iron; and it differs from sphene, of which it has been considered avariety, in containing very little silica and no titanium.

Obs. Accompanies quartz, albite, feldspar, Critchtonite, and anatase, at Mount Sorel, in Dauphiné. It was distinguished by Levy, and named in honor of Mr. Turner, in whose collection it was first found.

ORDER VI. HYALINEA.

ANDALUSITE. Andalusius prismaticus.

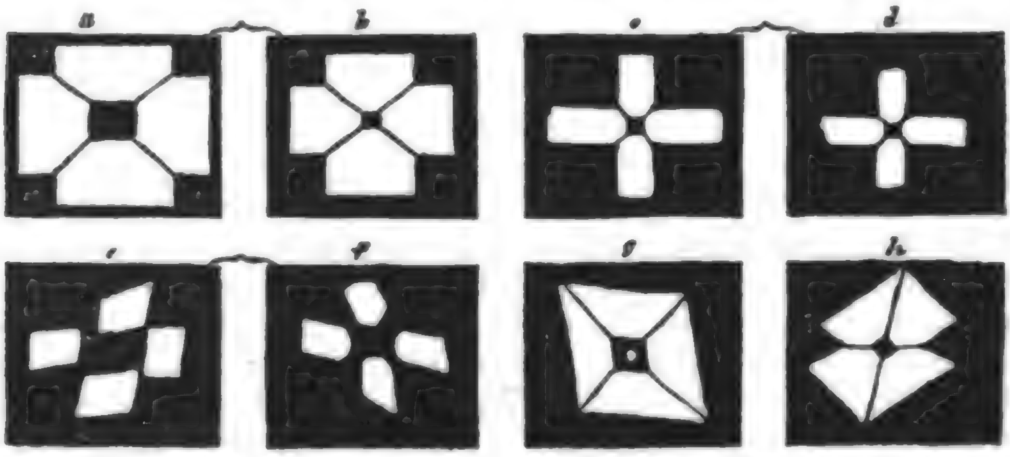
Prismatic Andalusite, *M.* Disilicate of Alumina, *Thom.* Feldspath Apyre, *H.* Macle. Chiastolite. Crucite.



373. *Primary form:* a right rhombic prism; M : M=91° 33′, and 88° 27′, *Secondary form:* $\bar{e}:\bar{e}=128°\ 6'$, $M:\bar{e}=161°\ 43'$, $P:a=144°\ 44'$. *Cleavage* parallel to M distinct. *Imperfect crystallizations:* indistinctly columnar and also granular.

H.=7·5. G.=3·13—3·32. *Lustre* vitreous. *Streak* white. *Color* flesh red, passing into pearl-gray. Subtranslucent—nearly opaque. *Fracture* uneven. Tough.

The variety chiastolite varies in its hardness from 3 to 7·5, owing to the impurities of its crystals. These crystals generally present a tesselated appearance, as if formed by the union of four separate individual crystals, of a grayish-white color, with the borders and interstitial spaces filled with the dark material that composes the gangue. This peculiar structure is exhibited in the following figures,



which are copied from a valuable memoir on this subject, by C. T. Jackson, in the Journal of the Boston Natural History Society, vol. i. p. 55, in which the author proposes the union of the two hitherto distinct species. Andalusite and Chiastolite. The same had been previously suggested by F. S. Beudant, (Traité de Min. p. 159, 1824.) The propriety of their union is fully established by Mr. Jackson, from an examination of a large number of specimens, in which he finds an insensible gradation, from those of the lowest degrees of hardness to crystals of the hardness of Andalusite. Moreover, the internal parts of the crystal have an irregularly rhombic form, sufficiently distinct to prove that the supposition is not inconsistent with the crystalline form of Andalusite. The hypothesis of Beudant, to account for these freaks in nature, appears to be the most consistent with the appearances presented, that is, that they are simple crystals, with extraneous matter, regularly arranged by the process of crystallization. This is a common effect of crystallization from a medium containing any impurities mechanically suspended, and it fully accounts for the occurrence. The irregularity of the whitish prisms, in the different parts of the same crystals, (figs. *a* and *b*, are from opposite extremities of the same crystal; so also *c* and *d*, and *e* and *f*,) appear to oppose the hypotheses of the compound nature of these crystals. Figure *h* appears to be the only one of the above sections, which belongs to a compound crystal. The chemical constitution of this variety, as determined by Jackson, is sufficient to settle the question of their identity.

Andalusite contains, according to Brandes, (Schweigger's Journ. xxv. 113,) Bucholz, Thomson, and Jackson,

	Tyrol.		Tyrol.	Var. Chiastolite.
Silica	34·000	36·5	35·304	33·0
Alumina	55·750	60·5	60·196	61·0
Potash	2·000	—	—	—
Protox. Iron	3·375	4·0	1·324	4·0
Prot. Mang.	0·625	—	—	—
Lime	2·125	—	—	—
Magnesia	0·375	—	1·000	—
Water	1·000	—	2·032	1·5
	99·250, Br.	101·0, Buch.	100·856, Thom.	99·5, J.

Before the blowpipe, *per se*, it does not melt, but whitens in spots. When pulverized and mixed with borax, it fuses with extreme difficulty into a transparent colorless glass.

Obs. Andalusite occurs only in primitive strata. It was first observed in the province of Andalusia, in Spain. In the Linsenz valley, above Innspruck, in the Tyrol, it occurs in large crystallizations; other foreign localities are Braunsdorf in Saxony; Galdenstein in Moravia; in Bavaria; in Siberia; at Botriffney, in Banffshire, in gneiss; at Killeny Bay, Ireland, in mica slate. The chiastolite variety occurs at Jago di Compostella, in Spain, Baréges, in the Pyrenees, the Bayreuth, and Cumberland, England.

At Westford, Mass., it is found abundantly, both crystalline and massive; Litchfield, Conn., has afforded a few fine crystals. Chiastolite is very abundant in the towns of Lancashire and Sterling, Mass., and at the former place occasionally in quartz, presenting all the essential characters of Andalusite. It is met with also near Bellows Falls, Vermont.

KYANITE. Epimecius cyaneus.

Prismatic Disthene-Spar, *M.* Disthene, *H.* Cyanite. Fibrolite,[*] Sappar, Rhœtizit, *W.*

374. *Primary form:* an oblique rhomboidal prism; P : M=93° 15′, P : T=100° 50′, M : T=106° 15′. *Secondary form:* the primary with the obtuse lateral edge, or with both obtuse and acute lateral edges replaced. M : ē=145° 16′, T : ē=140° 59′, M : ĕ=131° 25′, T : ĕ=122° 20′. *Cleavage* perfect parallel with M, less distinct parallel with T and ē. Crystals usually long and flat prisms, often laterally aggregated and divergent, straight or curved;

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[*] For remarks on the identity of kyanite and fibrolite, see an article by Prof. L. Vanuxem, in Journ. Acad. Nat. Sci. of Philad. VI. 41.

occasionally fine fibrous. *Compound crystals:* composition of the *first kind;* parallel to M.

H.=5—7; the lowest degrees on M, the highest on the solid angles and terminal edges. G.=3·559—3·675; the former of a milk-white variety of Rhœtizite, the latter of a blue transparent specimen which had been cut and polished. *Lustre* pearly upon M, particularly the cleavage face; inclining to vitreous on other faces. *Streak* white. *Color* blue or white prevalent; also gray, green, and even black; frequently blue along the axis of the crystal, and white each side. Transparent—subtranslucent. *Fracture* uneven. Brittle.

It contains, according to Arfwedson, (Kong. Veten. Acad. Handl. 1821, p. 147,) and Chenevix,

Silica	34·33	36·9	37·0	38·00
Oxyd of Iron	——	——	——	0·75
Alumina	64·89=99·22, A.	64·7=101·6, A.	62·5=99·5, A.	58·25=97·00, C.

Unaltered before the blowpipe, *per se.* With borax it fuses slowly into a transparent colorless glass.

Obs. The white varieties of this species were formerly considered as forming a distinct species, under the name of *Rhœtizite. Fibrolite* is also a variety of this species; it commonly occurs in shorter crystals, having a structure somewhat fibrous, whence its name. In other respects it is identical with kyanite.

Gneiss and mica slate are the principal repositories of kyanite. It is often accompanied by garnet and staurotide.

Transparent crystals of this species are met with at St. Gothard, in Switzerland, Styria, Carinthia, Bohemia; Villa Rica, in South America, also afford specimens of this species. A fine blue lamellated variety is found at Botrifny, in Banffshire. The white or *rhœtizite* variety, occurs principally at Kemeten, in the Pfitsch Valley, Tyrol. The foreign locality of fibrolite is in China, and the Carnatic, where it is associated with corundum.

Chesterfield, Mass., affords fine specimens of this mineral. It occurs there in long slender prisms, with white sides and blue central line, in mica slate, which contains also garnet. At Litchfield, Conn., it occurs in large rolled masses, and is associated with corundum and massive apatite. It is also abundant near the old iron furnace, two miles N. E. from Chancellorville, Spotsylvania Co., Va. Fibrolite is met with in prismatic crystals, from one to two inches long, at Bellows Falls, Vt., imbedded in gneiss; at Westfield and Lancaster, Mass.; near Wilmington, Delaware, in fine fibrous crystallizations, occasionally approaching to bladed lamellar; also on the Schuylkill river, back of the Robin Hood tavern, on the Ridge-road; and on the road to Cooper's Gap, in Rutherford Co., N. C. A black variety occurs in North Carolina, accompanied by crystals of Rutile. Near Philadelphia, it occurs in gneiss on the Springfield road, about two hundred yards from the Darnley bridge.

Kyanite, when blue and transparent, and in sufficiently large masses, is employed as a gem, and has some resemblance to sapphire.

This species was named because of its color, from κυανος, *blue.* The name, sappare, arose from a mistake by Saussure, in reading a label of this mineral, on which it was named *sapphire.*

WŒRTHITE.

375. Has been observed only in rolled masses, having a foliated crystalline structure.

H.=7·25. G. above 3. *Lustre* similar to that of kyanite. *Color* white. Translucent.

It contains, according to Dr. Hess, (Pogg. Ann. xxi. 73,)

Silica	40·58	41·00
Alumina	53·50	52·63
Magnesia	1·00	0·76
Water	4·63	4·63
Peroxyd of Iron	trace=99·71.	—=99·02.

Heated in a glass tube it becomes opaque, and gives out water. It dissolves slowly with borax, but undergoes no perceptible change with salt of phosphorus. When moistened with nitrate of cobalt, and strongly heated, it gives a beautiful dark-blue.

OBS. This species was discovered by Mr. Von Wörth, of St. Petersburgh, and an account of it published by Dr. Hess. It has been considered a variety of kyanite.

DIASPORE. EPIMECIUS DISSILIENS.

Euklastic Disthene-Spar, *Haid.* Dihydrate of Alumina, *Thom.*

376. *Primary form:* according to Phillips, an acute oblique rhomboidal prism; P : M=71° 30′, P : T=78° 40′, M : T=65°; according to Mohs, a rhombic prism of 130° may be obtained by cleavage. It occurs in irregular lamellar prisms.

H.=6—6·5. G.–3·4324, Haüy. *Lustre* vitreous, brilliantly splendent on cleavage faces. *Color* greenish-gray, or hair-brown. When thin, translucent—subtranslucent.

It contains, according to Vauquelin (Ann. de Chimie, xlii. 113) and Children, (Ann. Phil. 2d ser., iv. 146,)

Alumina	80·0	76·06
Protoxyd of Iron	3·0	7·78
Water	17·3=100·3, V.	14·70=98·54, C.

In the blowpipe flame it decrepitates with violence, and splits into numerous scaly particles, which fuse readily with borax into a colorless glass. According to Berzelius, these particles, after being slightly heated, will restore the blue color of reddened litmus paper. Mr. Children did not succeed in obtaining this result.

OBS. The locality of diaspore was for a long time unknown. Mr. Fieldler has lately reported that it occurs in a primary limestone, not far from Ekatherinenburg, in the Marmorbruch, at the back of the Koroibrod. Its superior lustre distinguishes it from Kyanite, some varieties of which it much resembles.

Diaspore is so named from its action under the blowpipe, from διασπειρω, *to scatter.*

SILLIMANITE. EPIMECIUS SILLIMANIANUS.

Bowen, Jour. Phil. Acad. Nat. Sc. III. 375. American Journ. of Science, VIII. 113.

377. *Primary form:* a rhombic prism; whether right or oblique is uncertain. The interfacial angle M : M, varies from 110° to 98°; those crystals in which the faces M are smooth and plain, present the latter, which therefore appears to be the correct angle of the primary rhombic prism. The specimens which afford a greater angle, are longitudinally striated, thus evincing some irregularity in the crystallization. *Cleavage* highly perfect, parallel to the longer diagonal, and producing brilliant surfaces; parallel to

M indistinct. The crystals are usually very long and slender; often curved, parellel, or slightly divergent, or traversing the gangue in various directions.

H.=7—7·5. G.=3·2—3·238, the latter the result of the author's trials. *Lustre* vitreous, inclining to pearly; hardly shining on M. but splendent on the face of perfect cleavage. Parallel to P, vitreous, inclining to resinous. *Streak* white. *Color* hair-brown—grayish-brown. Translucent. *Fracture* uneven, parallel to P. Brittle. The long crystals are detached from the rock entire, with great difficulty, on account of their frangibility.

It contains, according to Bowen and Muir,

Silica	42·666	38·670
Alumina	54·111	35·106
Zirconia	——	18·510
Oxyd of Iron	1·999	7·216
Water	0·510=99·286, B.	——=99·502, M.

These analyses are apparently quite unlike. But probably, as the amount of zirconia and alumina in Muir's analyses equals the alumina in that by Mr. Bowen, the zirconia is included by Mr. Bowen with the alumina.

Before the blowpipe, both *per se*, and with borax it is infusible.

Obs. It has been suggested that this species is but a variety of Bucholzite. Future examinations may possibly prove this to be the fact. But the analyses heretofore made, show so great a discrepancy, that it would be premature to unite them till their identity has been proved by farther investigations. Bucholzite has never been observed sufficiently crystallized to exhibit the similarity or dissimilarity of their crystallization. They differ considerably in hardness, and also in other of their physical characters.

Sillimanite occurs in slender prisms, thickly traversing quartz, in a vein of gneiss, at Chester, Conn. It was named by Bowen, in honor of Prof. B. Silliman, of Yale College.

BUCHOLZITE. Epimecius Bucholzianus.

Brandes, Schweigger's Jour. XXV. 125, 1819. *Thomson*, Roy. Trans. XI. 263. Anhydrous Silicate of Alumina, *Thom.*

378. Imperfectly crystalline; structure fibrous.

H.=6—7. G.=3·19. *Lustre* pearly and glistening. *Streak* white. *Color* white, or gray, inclining to yellow. Thin fragments slightly translucent—subtranslucent. *Fracture* conchoidal, perpendicular to the fibres. Brittle, and easily frangible.

It contains, according to Brandes and Thomson,

	Tyrol.	Chester, Penn.
Silica	46·0	46·40
Alumina	50·0	52·92
Potash	1·5	——
Oxyd of Iron	2·5=100, B.	trace=99·32, T.

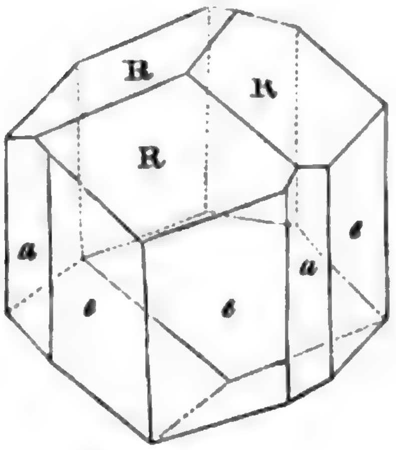
Obs. Bucholzite was originally obtained from Fassa, in the Tyrol. It has since been discovered at Chester, Pennsylvania, on the Delaware. Bucholzite is named after Bucholz, a celebrated German chemist.

TURMALINE. TURMALUS RHOMBOHEDRUS.

Rhombohedral Tourmaline, *M.* Schorl. Rubellite. Indicolite. Aphrizite. Aphrite, *W.* Turmalin. Tourmaline Apyre, *H.*

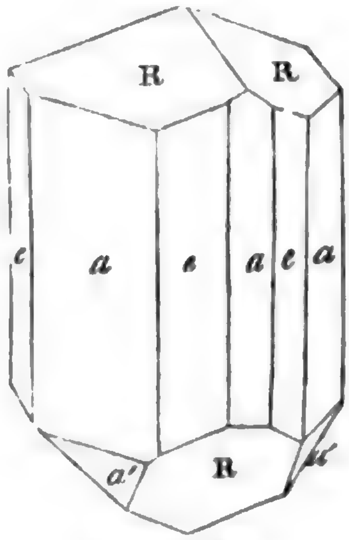
379. *Primary form:* an obtuse rhombohedron; R : R=133° 26′. *Secondary forms:* fig. 110, Pl. II., also the annexed figures:

1.



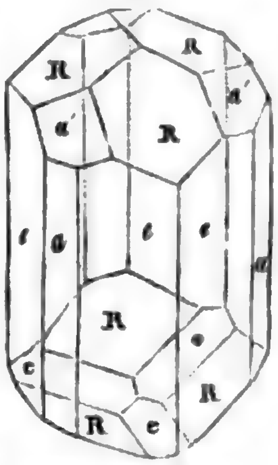
Monroe, Conn.

2.



Haddam, Conn.

3.



Gouverneur, N. Y., Newton, N. J.

R : e=156° 43′, R : *a′*=140° 40½′, e : e=155° 9′, R : *e*=113° 17′, *e* : *a*=150°, *e* : *e*=120°. Crystals often hemihedrally modified, or having dissimilar extremities. *Cleavage* parallel with R and *e*, difficult. *Imperfect crystallizations:* columnar, of various sizes of columns; often thin parallel, or divergent; sometimes the columnar particles are distinct, at others, closely aggregated into a compact mass, striated externally; granular structure rare.

H.=7—8. G.=3·076, Haidinger; 3·021, a transparent red turmaline from Paris, Maine, Shepard. *Lustre* vitreous. *Streak* white. *Color* black, brown, blue, green, red, and rarely white; sometimes red internally, and green externally; again, some specimens are red at one extremity, and green, blue, or black, at the other. Occasionally all these colors appear in the same crystal. Transparent—opaque; less transparent, viewed in the direction of the axis, than when at right angles with it, and often exhibiting different tints of color in the two directions. Some varieties are bluish, viewed parallel to the vertical axis, and red, perpendicular to it; others are liver-brown in one direction, and reddish-brown in the other. *Fracture* subconchoidal—uneven. Brittle.

The different colored turmalines contain, according to Gmelin and Arfwedson,

	Black.	Black.	Green.	Red.	Red.
Silica	33·048	35·20	40·30	42·127	39·37
Alumina	38·235	35·50	40·50	36·430	44·00
Lime	0·857	0·55	—	1·200	—
Protox. Iron	23·857	17·86	4·85	—	—
Magnesia	—	0·70	—	—	—
Potash	—	—	—	2·405	1·29
Soda	3·175	2·09	—	—	—
Boracic Acid	1·890	4·11	1·10	5·744	4·18
Lithia	—	—	4·30	2·043	2·52
Protox. Mang.	—	0·43	1·50	6·320	5·02
Moisture	—	—	3·60	1·313	1·58
	101·062, G.	96·44, G.	96·15, Arfw.	97·582, G.	97·96, G.

The action of these varieties before the blowpipe is quite various. In general, they more or less intumesce, some fusing readily, particularly those which contain lime, others assuming a slaggy appearance, without melting, while others, especially the red variety, are not acted on at all. When heated, they exhibit polarity, the most modified extremity becoming positive, and the other negative. In this particular it resembles other hemihedrally modified crystals. At a certain temperature it loses its polarity, but exhibits it again on cooling. Its polarity continues with the decrease of temperature, until it reaches 32° F.; a continued increase of cold re-excites the electric polarity, though with reversed poles. If the excited crystal be broken, each part thus produced will equally possess polarity; and even in the powdered state, it retains its pyro-electricity.

Obs. The different colors presented by this species have given rise to names designating these varieties. Blue turmalines have been termed *indicolite*, from their indigo-blue color; red turmalines, *rubellite;* and to the black, the name *schorl* was formerly applied. These names are, however, of no importance in the present state of the science. It is preferable to state the color, than call them by a name which might convey the idea that they were distinct species.

Turmaline is usually found in granite, gneiss, or mica slate. It also occurs in dolomite or primitive limestone. Its crystals are frequently very long, and pierce the gangue in every direction. Occasionally they occur short, not longer than broad, and when so, they are perfectly terminated at their extremities.

Black turmalines, of a large size, occur in Greenland, at Hörlberg, near Bodenmais, in Bavaria; at Karinbricka, in Sweden; and near Bovey, in Devonshire. Small brilliant crystals are met with, imbedded in decomposed feldspar, at Andreasberg, in the Hartz, forming the variety called *Aphrizite*. Rubellite occurs in a species of lithomarge, near Ekatherinenburg, in Siberia; pale yellowish brown crystals are found in talc, at Windisch Kappell, in Carinthia; white specimens come from St. Gothard and Siberia.

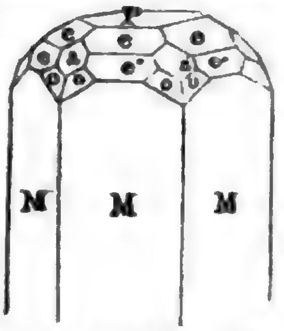
In the United States, magnificent specimens of red and green turmalines have been found at Paris, Maine. Some transparent crystals from this locality exceed an inch in diameter, and present a clear red color, internally surrounded by green; or are red at one extremity, and green at the other. Blue and pink varieties, most commonly imbedded in lepidolite, are still to be obtained at this place. Red and green turmalines occur also at Chesterfield, Mass., in a narrow vein of granite traversing gneiss. The crystals are commonly small and curved, nearly opaque, and exceedingly frangible. Green crystals often contain distinct prisms of a red color, especially when they occur in smoky quartz. Blue turmalines also occur at this locality. These crystals are accompanied by albite. At Goshen, Mass., similar varieties occur, and the blue turmaline is met with in greater perfection. Very perfect crystals, of a dark brown color, occur imbedded in mica slate, at Monroe, Conn. The crystals are commonly 1½ to 2 inches long, and nearly as broad; and uniformly they are perfectly terminated at the two extremities. (See fig. 1.) They are frequently aggregated in compound forms. Haddam, Conn., also affords fine black crystals, and occasionally some of quite a large size. They are profusely mingled in a mica slate, and associated with anthophyllite and hornblende. A cinnamon-brown variety is met with at Gouverneur, N. Y., imbedded in quartz, and also associated with scapolite, apatite, and sphene, in granular limestone. These crystals are often very highly modified; they occasionally exhibit the faces of a scalene dodecahedron, in addition to the terminal planes R and e. Similar specimens occur at Grenville, Lower Canada; also at Newton, N. J., associated with corundum, spinel, and rutile; and at Kingsbridge, N. Y., and Carlisle, Mass., with garnet.

The red turmaline, when transparent, and free from cracks and fissures, admits of a high polish, and forms a most beautiful and costly gem. A specimen from Siberia, presented to Mr. Grenville by the king of Ava, and now in the British museum, was valued at £500 sterling. The yellow turmaline, from Ceylon, is but little inferior to the real topaz, and is often sold for this gem. The green specimens, when transparent and firm, are also highly esteemed, but commonly the tint of color is, for the most part, dingy. Paris, Me., has afforded splendid gems of both green and red. The Siberian red turmaline, cut *en cabochon*, exhibits a milk-white chatoyant lustre.

It has been supposed that turmaline was known to the ancients under the name of *lyncurium*, (λυγκούριον,) which is described as having electrical properties. This name, however, was more probably applied to some variety of amber, which was so called from its supposed origin from the urine of the lynx. The identity of the red turmaline with the hyacinth of the Greeks, is more probable. The other varieties were either unknown, or possibly connected under a common name with other species of the same color. The turmaline received no attention from the moderns till Lemery, in the year 1717, published his discoveries. The word *turmaline* is a corruption of the name for this mineral at Ceylon, whence it was first brought into Europe. It has been gallicised into *tourmaline*; the original word does not contain the *o*. The name *schorl*, which has been applied to the black turmalines, and also some other mineral species, is reported to have been derived from Schorlaw, the name of a village in Saxony, which afforded specimens of this variety.

BERYL. Beryllus hexagonus.

Rhombohedral Emerald, *M*. Beryl. Aquamarine. Smaragd. Emeraude, *H*. Basaltes Hexahedrus, *Born*. Βηρυλλος. Σμαραγδος.



380. *Primary form:* a hexagonal prism. *Secondary forms:* fig. 125, Pl. II., also the annexed figure; M : a=119° 53′, P : a=150° 6′. M : a″=139° 1′, P : a″=130° 59′, P : a′=163° 3′, M : *e*=150°. *Cleavage* parallel with P; indistinct parallel with M. *Imperfect crystallizations:* rarely coarse columnar; occasionally large granular.

H.=7·5—8. G.=2·732, Haidinger, emerald variety; 2·678, an apple-green variety. *Lustre* vitreous; sometimes resinous. *Streak* white. *Color* green, passing into light-blue, impure yellow, and white. The brightest of these colors is emerald-green. Transparent—subtranslucent. *Fracture* conchoidal, uneven. Brittle.

It contains, according to Klaproth (Beitrage iii. 219 and 226) and Berzelius, (Afhandlingar, iv. 192,)

	Emerald.	Beryl.	From Broddbo.
Silica	68·50	66·45	68·35
Alumina	15·75	16·75	17·60
Glucina	12·50	15·50	13·13
Oxyd of Chromium	0·30	—	—
Peroxyd of Iron	1·00	0·60	0·72
Oxyd of Columbium	—	—	0·27
Lime	1·25=99·30, K.	—=99·30, K.	—=100·07, B.

Transparent varieties become clouded before the blowpipe; at a high temperature the edges are rounded, and ultimately a vesicular scoria is formed. A transparent colorless glass is obtained with borax.

Obs. Emerald and beryl are varieties of the same species, and are distinguished merely by their color; the former including the rich green transparent specimens, the latter those of other colors. The finest specimens of emerald are found in a vein of dolomite, which traverses a hornblende rock at Muso, near Santa Fé de Bogota, in Grenada. A perfect hexagonal crystal from this locality, two inches long, and about an inch in diameter, is in the cabinet of the Duke of Devonshire. It weighs 8 oz. 18 dwts., and though containing numerous flaws, and therefore but partially fit for jewelry, has been valued at 150 guineas. A more splendid specimen, though somewhat smaller, it weighing but 6 oz., is in the possession of Mr. Hope, of London. It cost £500. Mount Zalora, in Upper Egypt, affords a less distinct variety, and was the only locality which was known to the ancients. Other localities are Canjargum, in Hindostan, and Saltzburg, where it is imbedded in mica slate.

Pliny speaks of the finest beryls as those "qui viriditatem puri maris imitantur," and hence we apply to the crystals of beautiful shades of sky-blue, or mountain-green, the term aqua-marine. This variety has been found in Siberia, Hindostan, and Brazil. In Siberia, they occur in the granite district of Nertschinsk, and in the Uralian and Atai ranges of Siberia. They have been obtained exceeding a foot in length; they are commonly very deeply striated longitudinally. The most splendid specimen of this variety, of which we have any account, belongs to Don Pedro. It approaches in size, and also form, the head of a calf, and exhibits a crystalline structure only on one side: the rest is waterworn. It weighs 225 ounces troy, or more than 18¾ pounds. The specimen is perfectly transparent, and without a flaw; its color is a fine pale bottle-green. Less clear crystals of beryl occur at the Morne Mountains, England, county Down; at Cairngorum, in Aberdeenshire; at Limoges, in France; Finbo and Broddbo, in Sweden; Bodenmais and Rabenstein, in Bavaria, and elsewhere.

The United States have afforded some magnificent specimens of beryl; they are remarkable, however, only for their size. The largest has been found at Acworth, New Hampshire, about fifteen miles from Bellows Falls, where the beryls occur in an extensive vein of granite, traversing gneiss. It measured 4 feet in length, and 5½ inches across its lateral faces, and was therefore 11 inches in diameter. Its color was a bluish-green, excepting a foot at one extremity, where it passed into a dull green and yellow. Its weight was about 240 lbs. This locality affords smaller beryls in great perfection; they are usually of a pale yellow color; rarely a deep honey or wax yellow. Small regular crystals of beryl occur also at Bowdoinham and Topham, Me., in veins of graphic granite; their color is a pale green, or yellowish-white; also at Georgetown, Parker's Island, at the mouth of Kennebec river, associated with black turmaline. It also occurs at Goshen and Chesterfield, Mass., in irregular crystals of a pale green color, some of which are transparent; at Monroe, Conn., in a granite vein, of colors similar to the preceding; at Haddam, Conn., at the chrysoberyl locality, and also in the quarries of gneiss, each side of the river, presenting, at the former place, yellow and yellowish-green colors, and seldom regular forms; they often contain imbedded crystals of chrysoberyl and Columbite.

The emerald is supposed to derive its color from the presence of a minute quantity of oxyd of chrome, and beryl from a portion of oxyd of iron. This species affords some of the most splendid ornaments to the cabinet of the mineralogist, and in some of its varieties is among the richest of gems.

EUCLASE. BERYLLUS RHOMBOIDEUS.

Prismatic Emerald, *M.* Euclas, *W.* Euclase, *H.*

381. *Primary form:* a right rhomboidal prism; M : T=130° 50′. *Cleavage* perfect parallel to M and T.

H.=7·5. G.=2·907, Lowrey; 3·098, Haidinger. *Lustre* vitreous. *Streak* white. *Color* pale mountain green, passing into blue and white. Transparent; occasionally subtransparent. *Fracture* conchoidal. Very brittle and fragile.

According to Berzelius, (Kong. Vet. Acad. Handl. 1819, p. 136,) it contains

Silica	43·22
Alumina	30·56
Glucina	21·78
Peroxyd of Iron	2·22
Peroxyd of Tin	0·70=98·48.

Strongly heated in the blowpipe flame, it intumesces and becomes white; also melts into a white enamel, if the temperature is still farther increased. It becomes electric by friction, and retains this property for several hours, when once excited. It exhibits double refraction.

Obs. Enclase was originally brought from Peru; it has since been obtained in the mining district of Villa Rica, in Brazil. It is said to occur in chlorite slate, resting on sandstone. It generally possesses an agreeable and uniform color, and will receive a high polish; but it is useless as an ornamental stone, on account of its extreme fragility. This property induced Haüy to give it the name it bears, from ευ, *easily*, and κλαω, *to break*.

PHENACITE. Beryllus rhombohedrus.

Phenakite, *Nordenskiöld.* Poggendorf's Annalen, xxxi. 57.

382. *Primary form:* an obtuse rhombohedron; R : R=115° 25′, according to Nordenskiöld; 116° 40′, according to Beirich. *Secondary forms:* figs. 109 and 111, Pl. II.; also the two combined. *Cleavage*, according to Beirich, parallel to the primary faces.

H.=8. G.=2·969. *Lustre* vitreous. *Colorless;* also bright wine-yellow, inclining to red. Transparent—opaque. *Fracture* similar to that of quartz.

Hartwall obtained for its constitution, Silica 55·14, Glucina 44·47=99·61, with a trace of magnesia and alumina. It remains unaltered before the blowpipe, *per se*, but with borax fuses into a transparent glass. With carbonate of soda it affords a white enamel.

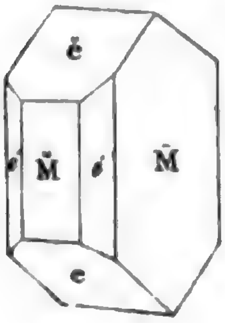
Obs. It occurs with emerald, imbedded in mica slate, in Perm, 85 wersts from Catherinenburg; also accompanied by quartz, in the brown ore of Framont. It was named by Nordenskiöld, its discoverer, from φεναξ, *a deceiver*, in allusion to its having been mistaken for quartz.

CHRYSOBERYL. Sapphirus rectangula.

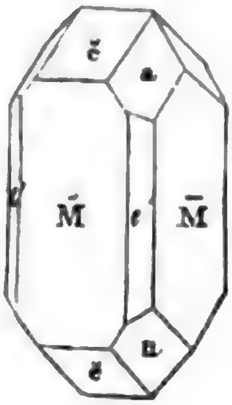
Prismatic Corundum, *M.* Cymophane, *H.* Krisoberill, *W.*

383. *Primary form:* a right rectangular prism. *Secondary forms:*

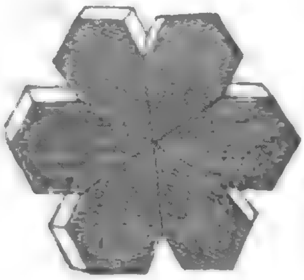
1.



2.



3.



M̆ : ĕ=120° 7′, ĕ : ĕ (adjacent planes) =119° 46′, M̆ : *e*=125° 20′, a : a (adjacent planes) =139° 53′, a : e=133° 8′. *Cleavage* parallel to M; less distinct parallel to M̆. *Compound crystals:* fig. 3; composition of the *second kind*, as explained in §§ 76, 77.

H.=8·5. G.=3·5—3·8; 3·597, specimen from Haddam, Conn.; 3·733, from Brazil. *Lustre* vitreous. *Streak* white. *Color* asparagus-green, grass-green, passing into greenish-white, and yellowish-green. Transparent—translucent. It sometimes presents a bluish opalescence internally. *Fracture* conchoidal, uneven.

It contains, according to Seybert (Silliman's Am. Journal, viii. 109) and Thomson, (Min. i. 401,)

	Haddam.	Brazil.		Brazil.
Alumina	73·60	68·666		76·752
Glucina	15·80	16·000		17·791
Silica	4·00	5·999		——
Protoxyd of Iron	3·38	4·733		4·494
Oxyd of Titanium	1·00	2·666		——
Moisture	0·40	0·666	Volatile Matter	0·480
	98·18, S.	98·730, S.		99·517, T.

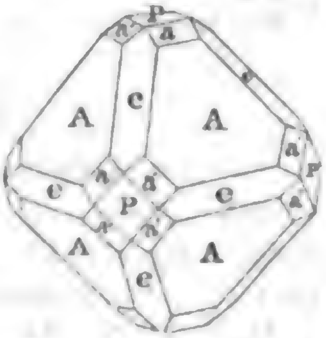
It is unaltered by the blowpipe, *per se*, and with soda the surface is merely rendered dull. It fuses with great difficulty, when mixed with borax, or salt of phosphorus.

Obs. Chrysoberyl occurs in Brazil, and also Ceylon, in rolled pebbles, in the alluvial deposits of rivers. At Haddam, Conn., it occurs crystallized, in granite traversing gneiss, and is associated with turmaline, garnet, beryl, automolite, and Columbite. It is found also in the same rock at Greenfield, near Saratoga, N. Y., accompanied by turmaline, garnet, and apatite.

When transparent and free from flaws, and of sufficient size, chrysoberyl is cut with facets, and forms a beautiful yellow gem. If opalescent, it is usually cut *en cabochon*. *Chrysoberyl* signifies *golden beryl*, (χρυσος, *golden*, βήρυλλος, *beryl*,) and was so named in allusion to its color. The same name was employed by the ancients for a different mineral, which possibly was chrysoprase. The name *Cymophane*, from κῦμα, *wave*, and φαινω, *to appear*, was applied to this species on account of the peculiar opalescence it sometimes exhibits.

SPINEL. Sapphirus octahedra.

Doderahedral Corundum, *M.* and *J.* Ceylanite. Pleonaste. Spinelle Ruby. Balas Ruby. Almandine Ruby. Rubicelle. Candite, *Bournon.* Zellanit, *W.* Alumine Magnésiée or Spinelle, *H.*



384. *Primary form:* the regular octahedron. *Secondary forms:* Pl. I. figs. 3, 7, 9, 3+9, 17, 21, and 3+9+17, as in the marginal figure, which represents a crystal from Hamburgh, N. J. *Cleavage* parallel to A, though obtained with difficulty. *Compound crystals:* fig. 128, Pl. II.; composition parallel with a face of the octahedron.

H.=8. G. (according to Haidinger) =3·523, of a red transparent variety; 3·575, of a black opaque variety called Ceylanite. *Lustre* vitreous; splendent—nearly dull. *Streak* white. *Color* red of various shades, passing into blue, green, yellow, brown, and black; occasionally almost white. Transparent—nearly opaque. *Fracture* conchoidal.

It contains, according to Berzelius, Thomson, Abich, and Descotils,

	Blue.	Dark green from U. S.	Black from U. S.	Red.	Pleonaste.
Silica	5·45	5·620	5·596	2·02	02
Alumina	72·25	73·308	61·788	69·01	68
Magnesia	14·63	13·632	17·868	26·21	12
Protox. Iron	4·26	7·420	10·564	0·71	16
Lime	—	trace	2·804	—	—
Water	—	—	0·980	protox. chrom. 1·10	—
	96·59, Berz.	99·980, Th.	99·600, Th.	99·05, Ab.	98, D.

Before the blowpipe, *per se*, it is infusible; but the red varieties change to brown, and even black and opaque as the temperature increases, and on cooling become first green, and then nearly colorless, and at last reassume their red color. It fuses with difficulty mingled with borax, but somewhat more readily with salt of phosphorus. The black varieties yield a deep green globule owing to the large amount of iron it contains.

Obs. The specimens of this species have been denominated, according to their colors, as follows: *pleonaste* has been applied to the black varieties; *spinelle ruby* to the scarlet colored; *balas ruby* to the rose-red; *rubicelle* to the yellow or orange-red; and *almandine ruby* to the violet colored. The *oriental ruby* belongs to the species sapphire.

Spinel occurs imbedded in granular limestone, and with calcareous spar in serpentine and gneiss. It also occupies the cavities of volcanic rocks. In Ceylon, Siam, and other eastern countries, it occurs, of beautiful colors, in rolled pebbles in the channel of rivers. The pleonaste variety is found at Candy, in Ceylon, and hence was called *Candite*, by Bournon. At Aker, in Sudermannland, Sweden, it is found of a pale blue and pearl-gray color, in primitive limestone. Small black crystals of splendent lustre occur at Vesuvius, in the ancient scoria of Mount Somma, associated with mica and idocrase; also imbedded in compact Gehlenite, at Monzoni, in the Fassathal.

Amity, N. Y., affords magnificent specimens of black spinel. They occur there with calcareous spar and Crichtonite in sepentine, often lining the sides of partial veins. Crystals are occasionally found sixteen inches in diameter; twins are of frequent occurrence. The same neighborhood affords an abundance of smaller crystals of various shades of green, black, red, and brown, imbedded in granular limestone with Brucite, hornblende, and pyroxene. At Hamburg, N. J., it occurs in calcareous spar and quartz, associated with scapolite, in crystals of rich shades of blue and green; they are frequently transparent. Newtown, N. J., affords pearl gray crystals, imbedded in limestone with blue corundum, turmaline, and rutile. Black crystals have been obtained at Monroe, N. Y., and green, blue, and occasionally red varieties, at Bolton, Boxborough, and Littleton, Mass., imbedded in primitive limestone.

The fine colored spinels, when of large size, are highly esteemed as gems.

AUTOMOLITE. SAPPHIRUS EUTOMA.

Octahedral Corundum, *N.* and *J.* Gahnite, *L.* Spinelle Zincifère, *H.*

385. *Primary form:* the regular octahedron. *Secondary form:* fig. 21, Pl. I. *Cleavage* parallel with the primary planes perfect. *Compound crystals* similar to fig. 129, Pl. II.

H.=7·5—8. G.=4·261, Ekeberg; often contains galena interspersed, and then gives a higher specific gravity. *Lustre* vitreous, inclining to resinous; commonly rather dull. *Streak* white. *Color* dark green, or black. Subtranslucent—opaque.

It contains, according to Ekeberg, (Afhand. i. 84,) and Abich, (Poggendorf's Annalen, xxii. 332,)

		Fahlun.	U. S.
Silica	4·75	3·84	1·22
Alumina	60 00	55·14	57·09
Magnesia	——	5·25	2·22
Oxyd of Zinc	24·25	30·02	34·80
Protoxyd of Iron	9·25=98·25, E.	5·85=100·10, A.	4·55=99·88, A.

From Abich's analysis it may be inferred, that automolite is composed of four atoms of alumina, and one of oxyd of zinc.

It is infusible, *per se*, before the blowpipe, and nearly so with borax or salt of phosphorus. With soda it melts imperfectly into a dark colored scoria, which, when fused again with the same reagent, deposits on the charcoal a ring of oxyd of zinc.

Obs. It occurs in talcose slate, at the mines of Nafversberg and Eric Matts, near Fahlun, in Sweden, and is associated with galena, blende, garnet, Gadolinite, &c. At Haddam, Conn., it is associated with chrysoberyl, beryl, garnet, and Columbite. This species was discovered by the celebrated Swedish chemist, Gahn, and was named in consequence Gahnite. It has since been denominated automolite by Haüy, from αυτομολος, *a deserter*, in allusion to the presence of oxyd of zinc in this mineral, which has no resemblance to an ore.

DYSLUITE. Sapphirus infusilis.

386. *Primary form:* the regular octahedron. *Secondary form:* fig. 9. Pl. I. *Cleavage* rather imperfect parallel with the primary faces. Surface rough.

H.=7·5—8. G.=4·551. *Lustre* vitreous, inclining to resinous. *Streak* paler than the color. *Color* yellowish-brown or grayish-brown. Subtranslucent—opaque. *Fracture* conchoidal.

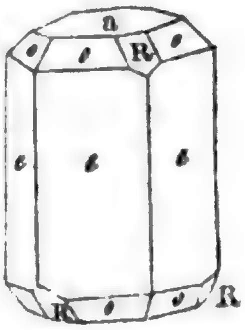
Its constituents, according to Thomson, (Min. i. 221,) are Alumina 30·490, Oxyd of Zinc 16·8, Peroxyd of Iron 41·934, Protoxyd of Manganese 7·6, Silica 2·966, Moisture 0·4=100·19.

It assumes a red color before the blowpipe, which it loses on cooling without any change from its original appearance. It dissolves slowly in borax, and not at all in carbonate of soda or salt of phosphorus. The bead obtained with borax has a deep garnet red color, and is transparent.

Obs. It occurs in small quantity at Sterling, N. J., disseminated through laminated calcareous spar, and associated with Franklinite and Troostite.

SAPPHIRE. Sapphirus rhombohedra.

Rhombohedral Corundum, *M.* Corundum. Emery. Oriental Amethyst. Oriental Topaz, Ruby, Emerald, Amethyst. Adamantine Spar. Salemstein. Schmirgel. Korund. Demantbpath. Telésie. Corindon. Asteria, *of Pliny*.



387. *Primary form:* an acute rhombohedron; R : R=86° 6′. *Secondary form:* R : *e*=136° 57′. R : *o*=154° 1½′, a : *o*=118° 51′, *o* : *e*=151° 9′. *Cleavage* parallel with a, in some varieties, perfect, but interrupted by conchoidal fracture; imperfect commonly in the blue variety. *Imperfect crystallizations:* in layers parallel to R, frequent; granular, often impalpable.

H.=9. G.=3·909—3·979. *Lustre* vitreous; in some specimens inclining to pearly on the plane a. *Streak* white. *Color* blue, red, yellow, brown, gray, and nearly white. The transparent blue varieties possess the highest specific gravity, and the red the least. Several varieties, when cut *en cabochon*, in a direction perpendicular to the axis of the prism, exhibits a bright opalescent star of six rays, corresponding to the hexagonal form of the crystal. Transparent—translucent. *Fracture* conchoidal, uneven. When compact, exceedingly tough.

It is composed of pure Alumina, according to Muir. The silica that different analyses have appeared to detect in it, has probably been derived from the mortar in which the mineral was abraded. It is unaltered in the blowpipe flame, both *per se* and with soda; it fuses entirely with borax, though with great difficulty; and also if pulverized with salt of phosphorus. It is not attacked by acids. Friction excites electricity, and in the polished specimens the electrical attraction continues for a considerable length of time.

Obs. The species sapphire includes corundum and emery, in addition to the finely colored varieties that have always borne this name. Corundum includes the gray and darker colored opaque crystallized specimens; emery, all massive varieties. The *red* sapphire is sometimes called the *Oriental ruby;* the yellow, *topaz;* the green, *emerald;* violet, *amethyst;* and hair-brown, *adamantine spar.*

Sapphire is principally found in the beds of rivers, either in modified hexagonal prisms, or in rolled masses, and is accompanied by grains of magnetic iron ore, and several species of gems. Corundum occurs in crystals, in a rock composed, according to Bournon, of feldspar, fibrolite, and several species of gems; also in dolomite and magnetic iron ore. Adamantine spar occurs in a kind of granite, containing no quartz, associated with magnetic iron ore, and the fibrolite variety of kyanite. Emery occurs in talcose slate.

The finest ruby sapphires occur in the Capelan mountains, near Syrian, a city of Pegu, in the kingdom of Ava; smaller individuals occur near Billin and Merowitz, in Bohemia, and in the sand of the Expaillie river, in Auvergne. Blue sapphires are brought from Ceylon; this variety was called *Salamstein* by Werner. Corundum occurs in the Carnatic, on the Malabar coast, in the territories of Ava, and elsewhere, in the East Indies; also near Canton, China. At St. Gothard it occurs of a red or blue tinge in dolomite, and near Morzo, in Piemont, in white compact feldspar. Adamantine spar is met with in large coarse hexagonal pyramids on the Malabar coast. Emery is found in large boulders near Smyrna, also at Naxos, and several of the Grecian islands. It occurs in talcose slate, at Ochsenkopf, near Schneeberg, in Saxony. Its color at this locality is a dark blue, or black, and its appearance is nearly that of fine grained basalt. A fine blue variety of sapphire occurs at Newtown, N. J., in an aggregate composed of hornblende, mica, feldspar, turmaline, iron pyrites, talc, and calcareous spar, the whole of which is connected with an extensive bed of primitive limestone. It is found more abundantly in detached boulders in the soil, between two small limestone ridges. The crystals are often several inches long, but do not present an external regularity of form. Well defined crystals of a bluish and pink color are found in a similar situation at Warwick, N. Y., where they occasionally occupy the cavities of large crystals of spinel. Pale blue crystals are met with at West Farms, Conn., near Litchfield, associated with kyanite. Isolated crystals have been found imbedded in the soil in North Carolina.

The red sapphire is much more highly esteemed than the other varieties of this species. A crystal weighing four carats, perfect in transparency and color, has been valued at half the price of a diamond of the same size. They seldom exceed a half inch in length. Two splendid red crystals, however, having the form of the scalene dodecahedron, and "de la longueur du petit doigt," with a diameter of about an inch, are said to be in the possession of the king of Arracan.

Blue sapphires occur of much larger size. According to Allan, Sir Abram Hume possesses a distinct crystal, which is three inches in length; and in Mr. Hope's collection of precious stones there is one crystal, formerly the property of the Jardin des Plantes, for which he gave the value of £3000 sterling. The sapphire admits of the highest degrees of lustre. It is cut by means of diamond dust, and polished on copper or lead wheels with the powder of emery, the massive variety of this species.

Pulverized emery is very extensively employed for cutting and polishing gems and silicious stones, and also for grinding and burnishing metallic wares.

The word *sapphire* is derived from the Greek, *σαπφειρος*, the name of a blue stone, highly valued by the ancients. From the descriptions of it, it does not appear to have been the sapphire of the present day, but the lapis lazuli, which more nearly agrees with the character given it by Theophrastus, Pliny, Isidorus, and others. The latter remarks, "Sapphirus cœruleus est cum purpura, habens pulveres aureos sparsos," particles of iron pyrites, which are very frequently disseminated through lapis lazuli, having been mistaken for gold. Corundum is a word of Asiatic origin.

SAPPHIRINE.

388. In small foliated grains. H.=7—8. G.—3·4282, Stromeyer. *Lustre* vitreous. *Color* pale blue, or green. Translucent. *Fracture* subconchoidal.

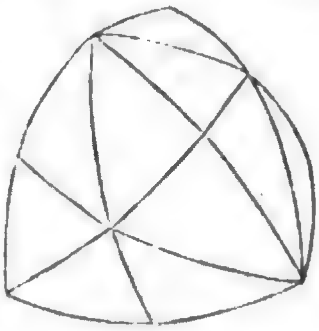
It contains, according to Stromeyer, Silica 14·507, Alumina 63·106, Magnesia 16·848, Lime 0·379, Protoxyd of Iron 3·924, Protoxyd of Manganese 0·529, Loss by ignition 0·492=99·784. Before the blowpipe, both *per se* and with borax, it is infusible; it is not altered by a strong red heat.

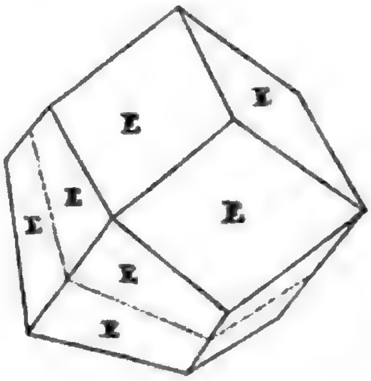
Obs. It is associated with mica and fibrous brown anthophyllite, at Fiskenaes, in Greenland, where it was discovered by Gièsecké. It was distinguished from sapphire, which it somewhat resembles, by Stromeyer.

DIAMOND. Adamas octahedrus.

Octahedral Diamond, *M.* Adamant. Demant, *W.* Diamant, *L.* and *H.* Ἀδάμας.

389. *Primary form:* the regular octahedron. *Secondary forms:* figs. 3, 5, 6, 7, 8, 9, 20, 41, Pl. I. The faces are very often curved, as in the marginal figure, which is the trigonal hemi-trisoctahedron represented with straight edges in fig. 41. *Cleavage* highly perfect parallel to the primary faces. *Compound crystals:* fig. 129, Pl. II.; composition parallel to the face of the octahedron. Also the second of the annexed figures, in which composition is of the same kind, (that is, parallel to the face of the octahedron;) but the form of the crystal is the secondary dodecahedron.





H.=10. G.=3·5295, Thomson; 3·488, Lowry. *Lustre* brilliant adamantine. *Streak* white. *Color* white—colorless; occasionally tinged yellow, red, orange, green, brown, or black. Transparent; translucent when dark colored. *Fracture* conchoidal.

It consists simply of carbon. It burns, and is perfectly consumed at a temperature of 14° Wedgwood, producing carbonic acid gas. It is not acted upon by acids or alkalies. Exhibits vitreous electricity when rubbed. Some specimens, exposed to the light of the sun for a short time, give out light when carried into a dark place. It possesses the power of refracting light to a very high degree.

Obs. It is, as yet, uncertain what rock is the original repository of this precious stone. It has been found in India in a species of conglomerate, composed of rounded silicious pebbles, quartz, chalcedony, &c., cemented by a kind of ferruginous clay; and in Brazil, in a very similar situation. Diamonds are usually, however, washed out from loose alluvial soil. It has been of late reported, that diamonds occur in the Uralian mountains, and M. Parrot describes them (Mem. de l' Ac. Imp. de St. Petersbourg, iii. 21, 1835) as occuring under the forms represented in fig. 20. Two that he examined contained small black uncrystallized particles in fissures, which he supposes to be vegetable carbon. This rather favors the hypothesis of their vegetable origin. Dr. Brewster was led by the effects of the diamond in polarizing light, the cavities it often contains, and the nature of its matrix in India and elsewhere, to advance this opinion in the Lond. and Edin. Jour. Oct. 1835, in which he supposes, "that the diamond originates like amber from the consolidation of, perhaps, vegetable matter, which gradually acquires a crystalline form, from the influence of time and the slow action of corpuscular forces."

In India, the diamond is met with in the district between Golconda and Masulipatam; near Parma, in Bundelcund, where some of the most magnificent specimens have been found; also on the Mahanuddy, near Ellore. The locality on the island of Borneo, is at Pontiana. In Brazil, the diamond grounds are comprised within the district of Minas Geraes. The river Gunil, in the province of Constantine, in Africa, is reported to have afforded some diamonds. The diamond has not hitherto been found in the United States. The late report of the discovery of one in North Carolina, weighing one and a half carats, requires confirmation.

The largest diamond of which we have any knowledge is mentioned by Tavernier, as in possession of the Great Mogul. It weighed, originally, 900 carats, or 2769·3 grains, but was reduced by cutting to 861 grains. It has the form and size of a half hen's egg. It was found in 1550, in the mine of Colone. The diamond, which formed the eye of a Braminican idol and was purchased by the Empress Catharine II. of Russia, from a French grenadier, who had stolen it, weighs 193 carats, and is as large as a pigeon's egg. The Pitt or regent diamond is of less size, it weighing but 136·25 carats or 419¼ grains, but on account of its unblemished transparency and color, it is considered the most splendid of Indian diamonds. It was sold to the Duke of Orleans, by Mr. Pitt, an English gentleman, who was governor of Bencolen, in Sumatra, for £130,000. It is cut in the form of a brilliant, and is estimated at £125,000. Napoleon placed it in the hilt of his sword of state. The Rajah of Mattan has in his possession a diamond from Borneo, weighing 367 carats. The mines of Brazil were not known to afford diamonds, till the commencement of the 18th century. The crystals they yield are seldom large. Maure mentions one of 120 carats, but they rarely exceed 18 or 20. The famous diamond, weighing 1680 carats, belonging to the emperor of Brazil, is supposed to be a topaz.

Colorless diamonds are the most highly esteemed. When cut and polished, a diamond weighing one carat is valued at £8; and the value of others is calculated by multiplying the square of the weight in carats by 8. The value of large diamonds increases, however, at a much more rapid rate. The grinding and cutting of diamonds is done entirely by the hand, and is accomplished principally by the mutual friction of two specimens, assisted by the powder of the diamond. This method was first discovered in 1456, by Louis Berquen, a citizen of Bruges. Previous to his time, the diamond was known only in its native uncut state.

The diamond, besides its use as an ornament, is exceedingly valuable for the purposes of engraving and cutting glass. The curvature of the crystalline faces much improves it for this purpose. The edges obtained by cleavage, or formed by the lapidary, are comparatively quite ineffectual in their cutting powers, and are never set for the glazier.

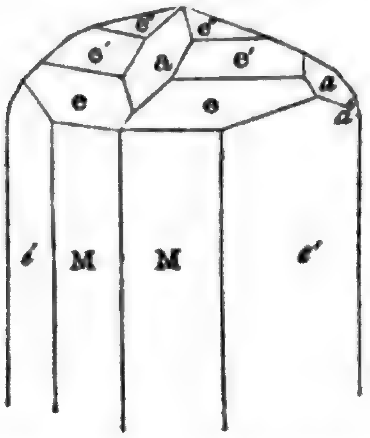
The term *Adamas*, was applied by the ancients to several minerals differing much in their physical qualities. A few of these are quartz, specular iron ore, emery, and other substances of rather high degrees of hardness, which cannot now be identified. It is doubtful whether Pliny had any acquaintance with the real diamond.

TOPAZ. Topazius rhombicus.

Prismatic Topaz, *M.* and *J.* Fluosilicate of Alumina, *Thom.* Physalite, Pyrophysalite, *Hisinger.* Pycnite. Schorlous Beryl. Schorlite. Schorlartiger Beril, *W.* Silice Fluatée Alumineuse, Alumine Fluatée Siliceuse, *H.*

390. *Primary form:* a right rhombic prism; M : M=124° 19′. *Secondary forms:*

1.



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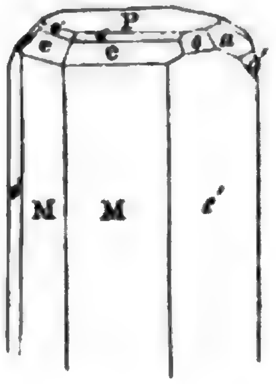


M : *e*=164° 24½′, *e* : *e* (adjacent planes) =86° 52′, M : e=135° 27½′, e : e=141° 7′, M : e′=124° 7′, e : e′=149° 38′, M : e″=116° 56′, e″ : e″=155° 37′, P : *a*=137° 29′, P : *a*′=117° 47′, *e*′ : *o*=131° 4′, P : *e*′= 138° 56′. *Cleavage* parallel to P highly perfect. *Imperfect crystallizations:* structure columnar—particles thin, long, and slightly coherent—lateral surfaces longitudinally striated; granular—particles of various sizes.

H.=8. G.=3·4—3·6. *Lustre* vitreous. *Streak* white. *Color* yellow, white, green, blue; pale. Transparent—subtranslucent. *Fracture* subconchoidal, uneven.

According to Berzelius, (Afhandlingar, iv. 236,) its different varieties consist of

	Saxon topaz.	Pyrophysalite.	Pycnite.
Silica	34·24	34·36	38·43
Alumina	57·45	57·74	51·00
Fluoric Acid	7·75=99·44.	7·77=99·87	8·84=98·27.

It is infusible alone, on charcoal, before the blowpipe, but when strongly heated the faces of crystallization are covered with small blisters, which crack as soon as formed. Some varieties assume a wine-yellow or pink tinge when heated. With borax it slowly forms a diaphanous glass. When pulverized it changes to green the blue solution of violets. Most topazes become electric by heat, and, if both terminations are perfect, exhibit polarity; the transparent varieties are, without difficulty, electrically excited by friction.

Obs. Pycnite has been separated from this species. It differs from topaz mainly in the state of aggregation of the particles, it presenting a thin columnar structure and forming masses imbedded in quartz. The *physalite* or *pyrophysalite* of Hisinger, is a coarse, nearly opaque variety, found in yellowish white crystals of considerable dimensions. This variety intumesces when heated, and hence its name from *φυσαω, to blow.*

Topaz is confined to primitive regions, and commonly occurs in granite, associated with turmaline, beryl, occasionally with apatite, fluor spar, and tin. With quartz, turmaline, and lithomarge, it forms the mixture called topaz rock by Werner.

Fine topazes are brought from the Uralian and Altai mountains, Siberia, and from Kamschatka, where they occur of green and blue colors. In Brazil they are found of a deep yellow color, either in veins or nests in lithomarge, or in loose crystals or pebbles. Magnificent crystals of a sky blue color, have been obtained in the district of Cairngorum, in Aberdeenshire. Jameson mentions a crystal from this locality, which weighed nineteen ounces. The tin mines of Schlaggenwald, Zinnwald, and Ehrenfriedersdorf in Bohemia, St. Michael's Mount in Cornwall, &c., afford smaller crystals. In the Mourne mountains it occurs in small limpid crystals, associated with beryl, albite, and mica, in the drusy cavities of granite. The physalite variety occurs in crystals of immense size, at Finbo, Sweden, in a granite quarry, and at Broddbo, in a boulder. A well defined crystal from this locality, in the possession of the College of Mines of Stockholm, weighs eighty pounds. Altenberg, in Saxony, is the principal locality of pycnite. It is there associated with quartz and mica.

Trumbull, Conn., contains the only known locality of this species in the United States. It seldom affords fine transparent crystals, except of a very small size. These are usually white; occasionally with a tinge of green or yellow. The large coarse crystals sometimes attain a diameter of several inches, (rarely six or seven,) but they are deficient in lustre, usually of a dull yellow color, though occasionally white, and often are nearly opaque. They sometimes present a few terminating planes of crystallization, in addition to the lateral faces. They are associated with magnetic pyrites, mica, and the chlorophane variety of fluor; also rarely with wolfram and tungstate of lime.

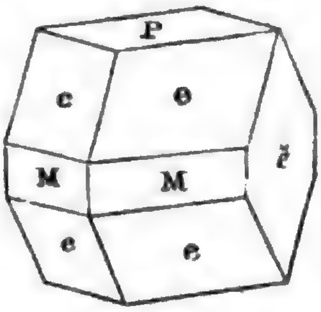
Topaz is employed in jewelry, and for this purpose its color is often altered by heat. The variety from Brazil assumes a pink or red hue, so nearly resembling the Balas ruby, that it can only be distinguished by the facility with which it becomes electric by friction. The finest crystals for the lapidary are brought from Minas Novas, in Brazil. From their peculiar limpidity, they are sometimes denominated *goutte d'eau*, and when cut with facets and set in rings, they are readily mistaken, if viewed by daylight, for diamonds. The coarse varieties of topaz may be employed as a substitute for emery in grinding and polishing hard substances.

The ancient τοπαζιον was found on an island in the Red Sea, which was often surrounded with fog, and therefore difficult to find. It was hence named from τοπαζω, *to seek*. This name, like most of the mineralogical terms of the ancients, was applied to several distinct species. Pliny describes a statute of Arsinoe, the wife of Ptolemy Philadelphus, four cubits high, which was made of τοπαζιον, or topaz, but evidently not the topaz of the present day, nor chrysolite, which has been supposed to be the ancient topaz. It has been conjectured that it was a jasper or agate; others have imagined it to be prase, or chrysoprase.

FORSTERITE. Topazius Vesuvianus.

Levy. Ann. Phil. 2d series, VII. 61.

391. *Primary form:* a right rhombic prism; M : M=128° 54′. *Secondary form:* M : e=142° 54′, P : e=127° 6′, e : e=(adjacent planes) 139° 14′, M : ĕ=115° 33′. *Cleavage* perfect and easily obtained parallel with P.



Scratches quartz. *Lustre* vitreous, splendent. *Streak* white. *Colorless.* Translucent.

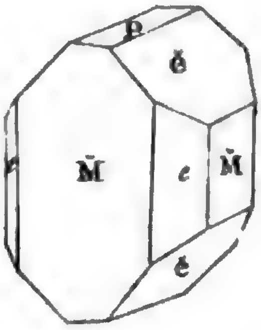
It contains, according to Children, Silica and Magnesia.

Obs. This species was first noticed by Levy in small crystals, accompanying spinel and olive-green pyroxene, on Mount Vesuvius. Its angles are nearly identical with those of chrysoberyl, but its cleavage parallel with P is quite peculiar.

CHRYSOLITE. Chrysolithus rectangulus.

Prismatic Chrysolite, *M* and *J*. Anhydrous Silicate of Magnesia, *Thom*. Peridot, *H*. Olivine, Chusite, Limbulite, *Saussure*. Krisolith, *W*.

392. *Primary form:* a right rectangular prism. *Secondary form:* P : ĕ=130° 27′, M̄ : ĕ=139° 33′, ĕ : ĕ=99° 7′, M̄ : *e*=155°, *e* : *e*=130° 2′. M̆ : *e*=114° 59′. *Cleavage* perfect parallel with M̆. *Imperfect crystallizations:* structure coarse or fine granlar—aggregated in irregular spheroidal masses, imbedded in rocks.



H.=6·5—7. G.=3·33—3·5; 3·41 of chrysolite, Haidinger; 3·3386—3·445 of olivine, Stromeyer; 3·3514 of chrysolite, Stromeyer. *Lustre* vitreous. *Streak* white. *Color* green, of various shades, commonly olive green; sometimes inclining to brown. Transparent—translucent. *Fracture* conchoidal.

Its different varieties contain, according to Stromeyer (Poggendorf's Annalen, iv. 194) and Walmstedt, (Kongl. Vet. Acad. Handl., 1824, p. 259,)

	Chrysolite.	Olivine.	Olivine.	Olivine.
Silica	39·73	40·09	38·48	40·83
Magnesia	50·13	50·49	48·42	47·74
Protox. Iron	9·19	8·17	11·19	11·53
Oxyd of Nickel	0·32	0·37	—	—
Oxyd of Manganese	0·09	0·20	0·34	0·29
Alumina	0·22	0·19	0·18	trace
	99·68, S.	99·51, S.	98·61, S.	100·39, W.

The two last are analyses of olivine from Siberian meteoric iron.

Chrysolite contains, therefore, an atom of each silica and magnesia, with a variable quantity of silicate of iron. From Mitscherlich's experiments, it appears that silicate of iron, and silicate of magnesia, are isomorphous.

Before the blowpipe chrysolite becomes somewhat darker, but does not fuse, or lose its transparency. With borax it forms a green transparent glass. The color of olivine is removed by nitric acid, the acid removing the iron, its coloring ingredient. It exhibits double refraction.

Obs. Those specimens of this species, which are perfectly crystallized, and present bright colors and high degrees of transparency, have been called pre-eminently *chrysolite;* while imbedded masses, less crystalline in their structure, and inferior in their diaphaneity and brightness of color, have been distinguished by the name *olivine*.

The perfectly crystallized chrysolite is brought from Constantinople: its locality is not known. Less distinct crystallizations occur imbedded in lava, at Vesuvius and the Isle of Bournon; imbedded in obsidian, at Real del Monte, in Mexico; among sand at Expaillie, in Auvergne, in pale green transparent crystals. Olivine is more abundant, being of frequent occurrence in basalt and lavas. Crystals, several inches in length, occur in greenstone at Unkle, near Boma, on the Rhine; spheroidal masses are met with at Kapferstein, in Lower Styria; and at Hecla and Vesuvius. It is a frequent ingredient of meteoric stones.

Olivine is commonly very fragile and often filled with cavities, and is therefore unfit for an ornamental stone. Chrysolite, also, is usually too much intersected by flaws to be valued as a gem; and when clear, is so soft as to require the greatest care to retain its polish.

The minerals *Chusite* and *Limbelite* of Saussure, from the volcanic district of Limbourg, appear to be decomposed varieties of this species.

Hyalosiderite is also commonly considered a variety of this species. According to Walchner, it occurs in crystals of a yellowish or reddish-brown color in amygdaloid, in the Kaiserstuhl, near Sasbach, in Brisgau. Its crystals are flat rectangular tables, with the terminal edges deeply replaced, ė : ė=99° 22′, ĕ : ĕ=77° 50′. Its streak is cinnamon-brown; internal lustre vitreous, external submetallic; subtranslucent. H.=5·5. G.=2·875. It is composed, according to Walchner, of Silica 31·634, Protoxyd of Iron 29·711, Magnesia 32·403, Alumina 2·211, Protoxyd of Manganese 0·480, Potash 2·788, and Chromium a trace=99·227. Before the blowpipe it becomes black, and then melts into a black bead, which is attracted by the magnet. It was discovered by Walchner, and described in Schweigger's Jahrbuch, ix. 65, 1823. The name is derived from ὑαλος, *glass*, and σιδηρος, *iron*.

The word *chrysolite* is derived from χρυσος, *gold*, and λιθος, *stone*, in allusion to its color.

LIGURITE. Chrysolithus obliquus.

393. *Primary form :* an oblique rhombic prism of 140° and 40°. H. above 5. G.=3·49. *Lustre* of the surface of fracture, between vitreous and resinous. *Streak* grayish-white. *Color* apple-green, sometimes speckled internally. Transparent—translucent. *Fracture* uneven.

It contains Silica 57·45, Alumina 7·36, Lime 25·30, Magnesia 2·56, Oxyd of Iron 3, Oxyd of Manganese 0·5=95·97, Viviani.

Obs. It occurs in a talcose rock, on the banks of the Stura, in the Apennines of Liguria. It does not become electric by heat, or by friction.

It is considered a superior gem to chrysolite, both in color, hardness, and transparency.

TAUTOLITE.

Philosophical Magazine, new series, III. 398.

394. *Primary form :* according to Mohs, trimetric. *Cleavage* only in traces.

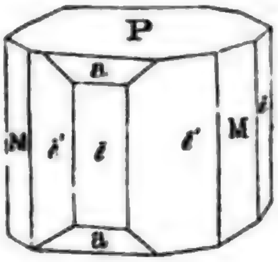
H.=6·5—7. G.=3·865. *Lustre* vitreous. *Streak* gray. *Color* velvet-black. Opaque. *Fracture* conchoidal, uneven. Very brittle.

Before the blowpipe it fuses into a black scoria, attractable by the magnet; with borax it forms a clear green glass. These and other reactions evince that the mineral contains silica, protoxyd of iron, magnesia, and alumina.

Obs. Occurs in the volcanic feldspathic rocks, in the vicinity of the Laachar-see, near Bonn, on the Rhine. It was first distinguished by Breithaupt, of Freiberg.

IOLITE. Hyalus bicolor.

Prismatic Quartz, *M.* Dichroite. Peliom. Steinheilite. Cordierite, *H.* Sapphire d'eau. Hard Fahlunite.



395. *Primary form :* a rhombic prism; M : M=120°. *Secondary form:* M : ē=150°, M : ĕ 120°. *Cleavage* parallel to P and ē, indistinct. *Imperfect crystallizations :* structure granular, strongly coherent; particles distinguished with difficulty.

H.=7—7·5. G.=2·5969, a Greenland specimen, Stromeyer; 2·651—2·6643, from Haddam, Conn., Thomson. *Lustre* vitreous. *Streak* white. *Color* various shades of blue, generally inclining to black; often deep blue, if viewed in the direction of the vertical axis, and brownish-yellow, or yellowish-gray, perpendicular to it. Transparent—translucent. *Fracture* subconchoidal.

It contains, according to Stromeyer and Thomson,

	Greenland.	Peliom, fr. Bodenmais.	Steinhillite.	Haddam, Conn.
Silica	49·170	48·352	48·525	49·620
Alumina	31·106	31·706	31·502	28·720
Magnesia	11·454	10·157	15·000	8·640
Lime	——	——	——	0·228
Protoxyd of Iron	6·338	8·316	1·610	11·580
Protox. Manganese	0·037	0·333	0·243	1 508
Water	1·204	0·595	1·705	——
	99·309, S.	99·459, S.	98·585, T.	100·296, T.

At a high heat before the blowpipe, it fuses on the edges into a blue transparent glass; with borax it slowly forms a clear bead. It is not acted on by acids.

Obs. Iolite is met with at Bodenmais, in Bavaria, occasionally in perfect crystallizations, but usually massive. It is associated with magnetic pyrites. The variety from this locality has been called *peliom*, from its peculiar smoky-blue color, from πελιος. It occurs in quartz, at Ujordlersoak, in Greenland; in granite, at Cape de Gata, in Spain; at Arendal, in Norway; at Orrijervi, in Finland; at Tunaberg, in Sweden, &c. Ceylon affords a transparent variety, in small rolled masses, of an intense blue color. At Haddam, Conn., it is associated with garnet and anthophyllite in gneiss.

It is occasionally employed as an ornamental stone, and when cut, exhibits its dichroism, or different colors, in different directions.

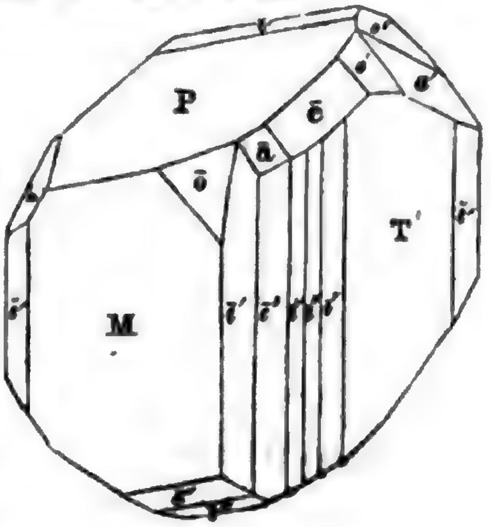
The name *iolite*, is derived from ιον, *a violet*, and λιθος, *stone*, in allusion to its color. From its property of exhibiting different colors, according to the direction in which it was viewed, it has also been named *dichroite*, from δις, *double*, and χροα, *color*.

A mineral, called *hydrous iolite*, has been analyzed by Bonsdorf, (Kong. Vet. Acad. Handl. 1827, p. 157,) which contains a considerable portion of water, in addition to the constituents of iolite; its constituents are as follows: Silica 45·05, Alumina 30·05, Magnesia 9·00, Protoxyd of Iron 5·30, Water 10·60=100. It occurs in modified six sided prisms, foliated parallel with the base, of a greenish-brown, or dark olive-green color; it presents the lustre of talc on its surface of fracture, but a waxy lustre on the surface of the plates; H.=3·75. It occurs in red granite, in the neighborhood of Abo, accompanied by a light bluish-gray iolite.

AXINITE. Hyalus acutus.

Prismatic Axinite, *M.* Thummerstein. Thumite. Yanolite.

396. *Primary form:* an oblique rhomboidal prism; P : M=134° 40′, P : T=115° 5′, M : T=135° 10′. *Secondary form:* M : ē′=179° 20′, M : ē″=174° 40′, P : ē=143° 20′, P : ō=133° 25′, P : *a*′=121° 30′, T : ĕ′=147° 55′, M : ĕ″=135° 12′. *Cleavage* indistinct and interrupted. *Imperfect crystallizations:* structure lamellar, lamellæ commonly a little curved; granular structure is occasionally observed.



H.=6·5—7. G.=3·271, Haidinger; a Cornish specimen. *Lustre* highly vitreous. *Streak* white. *Color* clove-brown, inclining to plum-blue and pearl-gray; occasionally green, from an admixture of chlorite; presents different colors viewed in two different directions. Transparent—subtranslucent. *Fracture* conchoidal. Brittle.

It contains, according to Vauquelin (Jour. des Mines, No. xxiii. 1) and Wiegman, (Schweig. Jour. xxxii. 462,)

Silica	44	45·00
Alumina	18	19·00
Lime	19	12·50
Magnesia	—	0·25
Protoxyd of Iron	14	12·25
Protoxyd of Manganese	4	9·00
Boracic Acid	— =99, V.	2·00=100, W.

It fuses readily before the blowpipe with intumescence, into a dark-green glass, which is blackened in the oxydating flame. Heat causes electrical excitement.

OBS. Axinite occurs in large clove-brown crystals, remarkable for the brilliancy of their lustre and perfection of form, at St. Cristophe, near Bourg d' Oisans, in Dauphiny, where it is associated with albite, Prehnite, and quartz. The silver mines traversing mica-slate, at Kongsberg, afford smaller crystals. It also occurs with hornblende, or magnetic iron ore, at Normark, in Sweden, and in rather complex crystals, of a dark color, at Botallack, in Cornwall; at this place it also occurs massive, forming a peculiar kind of rock, with garnet and turmaline. It is also met with at Thum, near Ehrenfriedersdorf, in Saxony, and hence has been called *Thumite*, and *Thummerstein*. Axinite was so called by Karsten, on account of the acuteness of the edges of its crystals, or their resemblance to an axe or hatchet, from 'αξίνη, *an axe*.

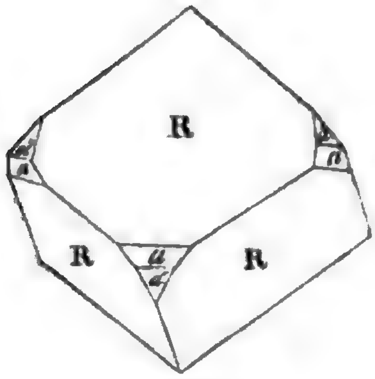
Axinite admits of a high polish, but is deficient in delicacy of color.

QUARTZ. Hyalus rhombohedrus.

Rhombohedral Quartz, *M.* Flint. Silex. Chalcedony. Cacholong. Agate. Jasper. Hornstone. Cat's Eye. Amethyst. False Topaz. Rose Quartz. Prase. Chrysoprase Cantalite. Iron Flint. Heliotrope. Eisenkiesel. Berg-crystal. Kalzedon.

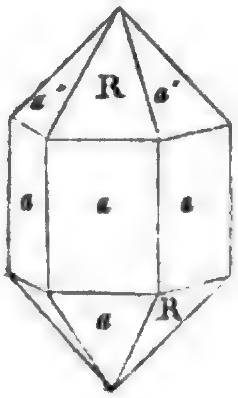
397. *Primary form:* an obtuse rhombohedron; R : R=94° 15′. *Secondary forms:* fig. 124, Pl. II., from Gouverneur, N. Y.; also the annexed figures:

1.

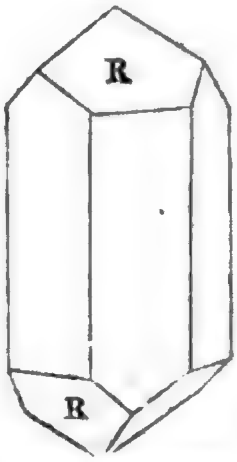


Chesterfield, Mass.

2.

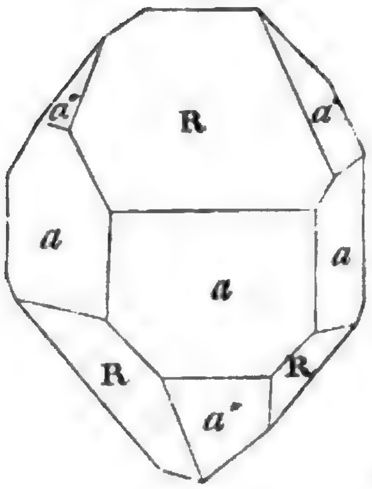


3.

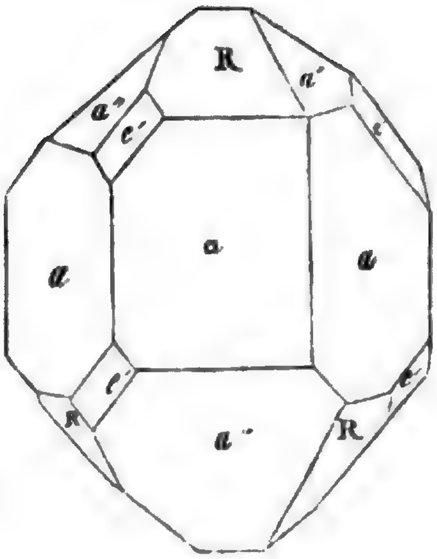


Compostella, Spain.

4

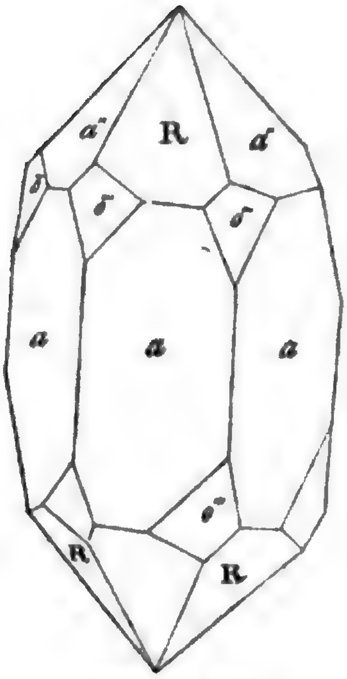


5.



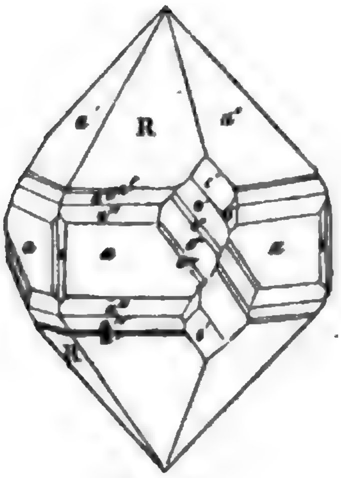
Fairfield, N. Y.

6.



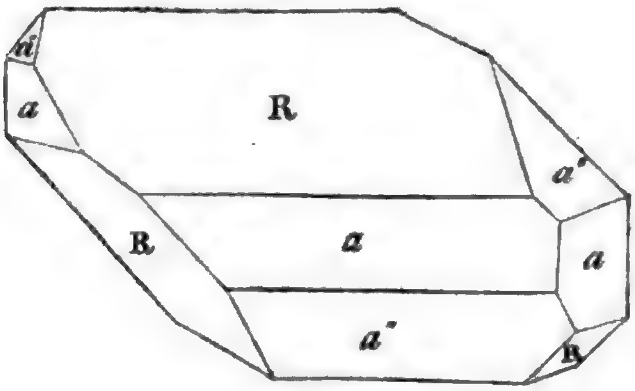
White Mts., N. H.

7.



Chamouny.

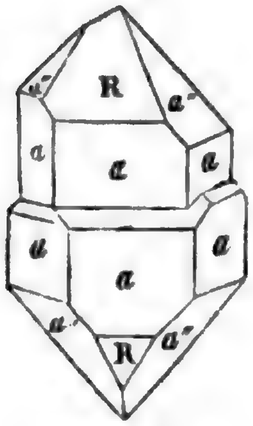
8.



Fairfield, N. Y.

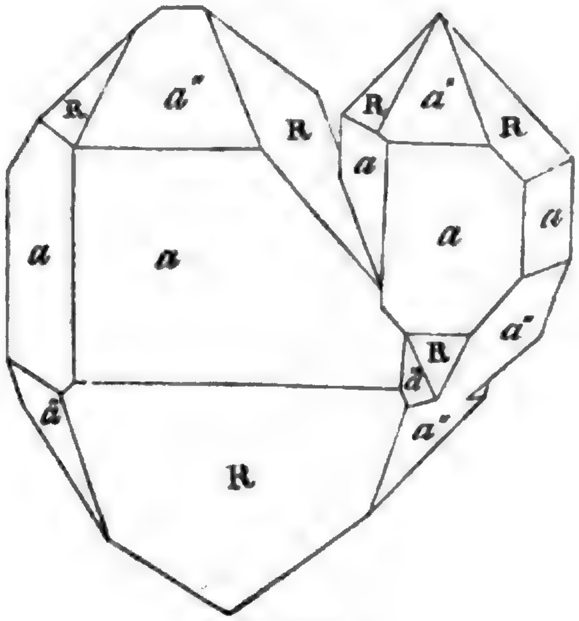
R : a=141° 47′, R : a''=133° 44′, R : e'=151° 5′, R : o''' (fig. 6,)= 148° 40′. *Cleavage* very indistinct, parallel to R and *a*. Sometimes obtainable by plunging a heated crystal into cold water. *Compound crystals :*

9.



Fairfield, N. Y.

10.



Fairfield, N. Y.

These are instances of postnatal composition ; they are of frequent occurrence. *Imperfect crystallizations :* stalactitic and mammillary forms, having an impalpably granular structure ; coarse columnar, surface crystalline ; delicately fibrous, rare ; massive, impalpable, or coarse granular. *Pseudomorphs :* imitative of the rhombohedron, scalene dodecahedrons, and hexagonal prisms of calcareous spar—of the lenticular crystals of gypsum—of cubes and octahedrons of fluor spar.

H.=7. G.=2·6413—2·6541, Beudant ; 2·6701, Haüy. *Lustre* vitreous, sometimes inclining to resinous ; splendent—nearly dull. *Streak* white, of pure varieties ; if impure, often the same as the color, but paler. *Color* white, when pure ; often various shades of yellow, red, brown, green, and blue. Transparent—opaque. *Fracture* perfect conchoidal—subconchoidal. Tough—brittle—friable.

The pure quartz crystal consists entirely of silica. Impure varieties contain variable quantities of iron, alumina, manganese, or nickel, &c. Before the blowpipe, *per se*, it undergoes no change, but fuses readily with carbonate of soda, accompanied with a brisk effervescence, into a transparent glass.

No mineral species assumes a greater variety of characters, both as respects color, lustre, and diaphaneity, than the one under consideration. A great part of the mineralogy of the ancients consisted in a knowledge of some forty or fifty varieties of this species, to which they applied distinct names. Many of their terms, and also others, are now in use, and therefore require an explanation. *Rock crystal* includes the limpid quartz. *Amethyst* is applied to a bluish-violet variety ; its color is due to the presence of a small quantity of manganese. *Smoky quartz* is a transparent, or translucent crystalline variety, having a smoky color. *Rose quartz* is a rose-red, translucent, massive variety. *Aventurine quartz* has a gray, brown, or reddish color, and contains interspersed scales of mica, producing, when polished, a spangle-like appearance. *Prase* is a dark leek-green, massive variety. *Ferruginous quartz* is a dull-yellow, or red, opaque variety; often in perfect and very regular crystals. *False topaz*, or *Cairngorum stone*, includes light yellow transparent crystals. *Milky quartz* has a milk-white color; it is called greasy quartz when its lustre is oily. *Chalcedony* is a translucent, or subtranslucent, massive, impalpably granular variety, often presenting imitative shapes. The color of the pure chalcedony is white, flesh-white, or bluish; when of other colors it is otherwise designated. *Chrysoprase* is a leek-green translucent Chalcedony: the color is owing to a small quantity of nickel; *Carnelian*, a clear red, or yellowish-red, sometimes grayish, translucent variety. *Jasper* is subtranslucent, or opaque, and may be either brown, yellow, or red, and is sometimes striped—it contains several per cent. of oxyd of iron, and a little alumina. *Cat's eye* is a light colored, usually greenish-gray, (sometimes yellow, red, or brown,) Chalcedony, containing filaments of asbestus, which give rise to an opalescent appearance when the stone is cut *en cabochon*. *Plasma* is of a dullish green color, with yellow and whitish dots, and a glistening lustre. *Heliotrope* has a deep green color, and contains interspersed blood-red spots. *Sard* is deep brownish-red, or blood-red by transmitted light. *Onyx* is composed of alternate layers of brown and opaque-white Chalcedony; when the layers consist of sard and milk-white Chalcedony, it is called *sardonyx;* when the layers are composed of various kinds of Chalcedony, and variously arranged, usually in concentric layers, it is called *agate:* if the Chalcedony contains dendrites of a brown or green color, it forms the *Mocha stone*,—so called from its Arabian locality. *Flint* is a dull-black, or grayish-black variety, (occasionally brown, yellow, or red,) and is commonly subtranslucent; fracture perfect conchoidal. *Hornstone* differs from flint in its splintery fracture, grayer color, and also in being more brittle; if the hornstone or flint exhibits a coarse slaty structure, it is called *flinty slate:* a very tough variety of flint, opaque, and of a grayish, or velvet-black color, has been distinguished by the name of *Lydian stone*, *touchstone*, or *basanite*. *Float stone*, or spongiform quartz, *quartz nectique*, of Hauy, is sufficiently light to swim on water; it consists of intermingled fibres, or acicular crystals, of a white or gray color, forming a spongy or porous mass.

Quartz, in some of its varieties, occurs in almost every rock-stratum. It is an essential constituent of granite, gneiss, and mica slate, and of the various silicious conglomerates and sandstones of a later period. It also forms extensive beds in primitive regions. The chalcedonic varieties occur principally in the vesicular cavities of trap, or basaltic rocks. Jasper is usually found as a rolled pebble. It also occurs in limestone, occupying the place of hornstone.

Switzerland, Dauphiny, Piedmont, the Carrara quarries, and numerous other foreign localities, afford fine specimens of the rock crystal. The most beautiful amethysts are brought from India, Ceylon, and Persia, where they occur in geodes, and as pebbles; inferior specimens occur in Transylvania, in large crystalline groups; in the vicinity of Cork, and on the island of May, in Ireland. The *false topaz* is met with in Brazil. *Rose quartz* occurs in a vein of manganese, traversing the granite of Rabenstein, near Zwiesel, in Bavaria. *Prase* is found in the iron mines of Breitenbrunn, near Schwartzenberg, in Saxony. The amygdaloids of Iceland, and the Faroe Islands, afford magnificent specimens of *Chalcedony;* also Huttenberg and Loben, in Carinthia, &c. A small blue variety, in hexahedral crystals, (pseudomorphs of fluor,) occurs at Treszytan, in Transylvania. The finest *carnelians* and *agates* are found in Arabia, India, Surinam, and Saxony. Perthshire, and other parts of Scotland, afford smaller, but handsome specimens. *Chrysoprase* occurs at Kosemutz, in Silesia. *Aventurine quartz*, at Cape de Gata, in Spain. *Cat's eye*, in Ceylon, the coast of Malabar, and also in the Hartz. *Plasma*, in India and China, whence it is usually brought in the form of beads. *Heliotrope*, in Bucharia, Tartary, Siberia, and the island of Rum, in the Hebrides. *Float stone*, in the chalk formation of Merril Montant, near Paris, and in some of the Cornish mines. The banks of the Nile afford the Egyptian jasper; the striped jasper is met with in Siberia, Saxony, and Devonshire. A fine *yellow jasper* is found at Vourla, bay of Smyrna, in a low ridge of limestone, to the right of the watering place, between the harbor and the high hills that commence their rise about a mile back. It is here associated with a beautiful opal, coarse carnelians, chrysoprase, and hornstone, and these minerals seem to occupy in the limestone the place of hornstone, which is found in various parts of the adjoining country, and also at Napoli di Romania, in Greece.

The Plains of Argos are strewed with pebbles of *red jasper*. A variety of sandstone occurs in thin layers at Villa Rica, remarkable for its flexibility, owing apparently to the dissemination of small scales of mica through the mass.

The black limestone of Quebec affords fine crystals of quartz. The smoky variety is obtained in large crystallizations in Nova Scotia. In the United States, beautiful specimens have been obtained in the primitive mountains of New Hampshire and Vermont; but they are rare. Small but remarkably clear and perfect crystals are found in various parts of the state of New York. At Middlefield, N. Y., on the banks of the West Canada Co., they occur in a calciferous sand rock, lying loose in large cavities, accompanied with a loose earth. Several hundred crystals are often obtained from a single cavity by prying open the rocks where fissured. The crystals are occasionally smoky, and often contain anthracite; rarely cavities occur filled with a fluid. They vary in size from the head of a pin to a length of four or six inches. Several parts of the adjoining country are strewed with crystals, which are turned up and exposed to view by the ploughman. Fine specimens of drusy quartz are obtained at the same locality. Gouverneur, N. Y., affords splendid dodecahedral crystals, similar to fig. 124, Pl. II., associated with an iridescent crystallized specular iron. They vary from three quarters to two inches in length, and commonly present prismatic faces, but in general, not more than a twentieth or sixteenth of an inch long. Diamond Island, Lake George, is an old locality of quartz crystals. Small unpolished crystals, nearly perfect rhombohedrons, (fig. 1,) occur in granite at Chesterfield, Mass. At the notch of the White mountains, N. H., and at the locality of turmaline, at Paris, Me., handsome crystals of brown or smoky quartz have been obtained. Druses of quartz, of a delicate apple-green color, occur with chrysoprase, at New Fane, Vt.; also of other colors at the same place.

Rose quartz occurs at Acworth, N. H., Paris, Me., and Southbury, Conn. Chalcedony, carnelian, and agates, occur occasionally in the trap region of Connecticut and Massachusetts; more abundandantly in the trap of Lake Superior, and also in rolled masses of much beauty, particularly at Keweena Point. The same locality affords smoky and amethystine quartz. Amethyst occurs also at the Pic Bay, and at Gargontwa, Lake Superior, crystallized in trap; also at Bristol, R. I., and occasionally throughout the trap region of Massachusetts and Connecticut. Red jasper is found in pebbles at Saugus, near Boston, and on the banks of the Hudson, at Troy; yellow jasper occurs with Chalcedony, at Chester, Mass.

Pseudomorphs, imitative of hexagonal and scalenohedral crystals of calcareous spar, occur at Williamsburg, Mass.

Quartz crystals occasionally occur of an enormous size. A group in the museum of the university at Naples, weighs nearly half a ton. A crystal, belonging to Sig. Rafelli, of Milan, measures three and a quarter feet in length, and five and a half in circumference, and is estimated at eight hundred and seventy pounds; another at Paris is three feet in diameter, and weighs eight cwt. Crystals often exhibit very beautiful internal iridescences, owing to fissures or fractures. This effect may be produced artificially, by heating the crystal nearly to redness and plunging it, while hot, into cold water. Foreign substances frequently penetrate or thoroughly permeate crystals of quartz. Iron has already been alluded to as one of these permeating substances. Chlorite is sometimes so thoroughly intermingled, that the crystals appear to be composed entirely of this material; their hardness, however, shows their silicious nature. Anthracite, asbestus, actinolite, rutile, turmaline, silver, and copper, are other penetrating substances.

Specimens containing acicular crystals of rutile, are often very beautiful. But the most interesting by far of the substances contained in quartz, are the fluids which occupy small cavities, and evince their presence on turning the specimens, by the motion of the accompanying air bubble, like the bubble in a spirit level. These cavities are sometimes of considerable size. Jacobson, of Copenhagen, possesses a geode of quartz, an inch and a quarter long, which contains at least half a cubic inch of fluid. This fluid is usually water; but occasionally it is a bituminous fluid resembling naphtha. Mr. Allan describes a crystal of amethyst in his collection, which contains four cavities partially filled with this peculiar fluid; at a temperature of 83°, the fluid dilates and entirely fills all the cavities, and as it reappears on cooling, an ebullition is apparent.

A very peculiar gelatinous substance, appearing to be silica in solution, has been observed on breaking open geodes; and the production of a species of Chalcedony from the subsequent evaporation has also been noticed. But the nature of the solvent of silica is not yet fully ascertained. It is, however, held in solution in the hot waters of the Geysers of Iceland, whose solvent power is supposed to be due to the presence of a small quantity of an alkali, and its high temperature. The Geysers have covered the part of Iceland in their vicinity, with a silicious sinter.

Several of the varieties of this species have long been employed in jewelry. The *amethyst* has always been valued as a gem of great beauty. Like most other stones, it is less brilliant by candle light, and at all times appears to best advantage, when surrounded with pearls and set in gold. The color of the amethyst is often irregularly diffused, as is well described by Pliny, "ad viciniam crystalli descendet albicante purpuræ defectu,"—purple, gradually fading into white. It was called *amethyst*, *αμεθυστος*, on account of its pretended preservative powers against intoxication, from *α*, *not*, and *μεθυω*, *to intoxicate*. This is not, however, the only *amethyst* of the ancients. The violet colored sapphire, the violet fluor spar, (scalpturis faciles, *Plin.*, *easily graven*,) and some other purple species, were designated by the same name; it has also been supposed, that garnet came under the same denomination.

On account of the arrangement of the colors of the onyx in layers, it is well adapted for the formation of cameos, and was the material formerly employed for this purpose. The most noted of the ancient cameos, is the Mantuan vase at Brunswick. It was cut from a single stone, and has the form of a cream pot, about seven inches high and two and a half broad; on its outside, which is of a brown color, there are white and yellow groups of raised figures, representing Ceres and Triptolemus in search of Proserpine. The Museo Borbonico, at Naples, contains an onyx measuring eleven inches by nine, representing the apotheosis of Augustus, and another, exhibiting the apotheosis of Ptolemy on one side, and the head of Medusa on the other; both are splendid specimens of the art, and the former is supposed to be the largest in existence.

The carnelian (sarda of Pliny) receives a fine polish, and is often rich in color; but is too common to be highly valued. When first obtained from the rock in which they occur, they are usually gray; they receive their fine colors from an exposure of several weeks to the sun's rays, and a subsequent heating in earthen pots. Agates (achates of the ancients) are very varied in their colors, and in the disposition of them. When arranged in zigzag parallel lines, the polished specimen presents delineations resembling a fortification; this variety is called the fortification agate. The Scotch pebble is usually of this kind. The colors of this stone are rendered more obvious by boiling it in oil, and afterwards in sulphuric acid; the latter carbonizes the oil absorbed by the apparently porous layers, and thus increases the contrast of the different colors. Agate are often made into mortars for chemical and pharmaceutical preparations, and according to Pliny, it was employed for the same purpose by the physicians of his day. In Germany it is made into cups and plates. The royal collection at Dresden contains a table service of German agate; and at Vienna, in the imperial cabinet, there is an oval dish 22 inches in length, formed from a single stone. The agate, or *achates* of the Greeks, was so called from the river Achates, in Sicily, whence, according to Theophrastus, these stones were originally brought. *Iaspachates* corresponded to our jasper agate; *Sardachates* contained layers of the sard, or carnelian; *Dendrachates* (from *δενδρον*, *a tree*, and achates) was our moss agate; *Hæmachates* (from *αιμα*, *blood*, and achates) was an agate, sprinkled with spots of red jasper.

The jasper admits of a brilliant polish, and is often formed into vases, boxes, knife-handles, &c. It is also extensively used in the manufacture of Florentine mosaics. The iaspis of the ancients, whence our word jasper is derived, appears to have included only the green or blue colored variety, together with some other stones, not of the jasper kind. Quartz is a necessary ingredient in the manufacture of glass and porcelain, and is also employed in the smelting of ores, particularly copper, and in other metallurgical operations. With lime it forms mortar. Its use in the state of flint is well known.

Porcelain jasper is sometimes referred to this species. It is, however, merely a clay, indurated by heat. It fuses readily, and is thus distinct from quartz. It occurs near Carlsbad, in Bohemia.

OPAL. Hyalus opalinus.

Uncleavable Quartz, *M.* Hyalite. Muller's Glass. Hydrophane. Menilite. Cacholong. Silicious Sinter. Pearl Sinter, Fiorite. Gyrasol. Eisenopal, *Haus.* Quartz Hyalin Concretionée, Quartz Résinite, *H.* Opalus, Pæderos, *Pliny.* ὀπάλλιος.

398. Impalpably granular structure; small reniform and stalactitic shapes, and large tuberose concretions. Pseudomorphs imitative of calcareous spar.

H.=5·5—6·5. G.=2·0—2·21. *Lustre* vitreous, frequently subvitreous, and often inclining to resinous, and sometimes to pearly. *Streak* white. *Color* white, yellow, red, brown, green, gray, generally pale; dark colors arise from foreign admixtures. Some specimens exhibit a rich play of colors; others present different colors by refracted and reflected light. The play of colors is destroyed by heat.

It consists of

	Hyalite.	Precious Opal.	Menilite.
Silica	92·00	90·0	85·5
Water	6·33=98·33.	10·0=100.	11·0=96·5.

Menilite often contains, also, small portions of iron, alumina, lime, and carbon. Before the blowpipe is infusible, but opal decrepitates readily, gives out water, and becomes opaque. Some varieties become red in consequence of the iron they contain.

The *precious opal* exhibits a delicately beautiful play of colors. *Fire opal*, or *girasol*, presents bright hyacinth-red and yellow tints. *Common opal*, and *semi-opal*, are common varieties, not exhibiting the opalescence of the precious or fire opal; they are distinguished from one another by their degrees of transparency and lustre. *Hydrophane* is a variety of opal which is not transparent, but becomes so when immersed in water. *Cacholong* is nearly opaque, and of a porcelain or bluish-white color; it adheres to the tongue, and contains a small portion of alumina. It is closely allied to, and often associated with hydrophane. *Hyalite*, or *Muller's glass*, occurs in small reniform botryoidal, and occasionally stalactitic shapes, either colorless or white. *Menilite* is a brown and opaque variety, occurring in compact reniform masses, occasionally presenting a slaty structure. *Opal jasper* contains several per cent. of iron, and is the analogue in this species of the jasper in the preceding. *Silicious sinter* is a loose silicious aggregate, deposited by the Geysers of Iceland, where it presents porous stalactitic, fibrous, "cauliflower-like," and occasionally compact concretions. *Pearl sinter*, or *fiorite*, occurs in the cavities of volcanic tufa, in smooth and shining globular and botryoidal masses, which have a pearly lustre. *Wood opal* has a peculiar ligneous structure.

Obs. Opal occurs in short irregular veins in porphyry; also in the vesicular cavities of amygdaloids. Common opal occurs in limestone, with hornstone. Menilite is met with in clayslate. Some varieties are found with galena and blende, in metalliferous veins. It also occupies the interior of fossils in sandstone.

The precious opal occurs in porphyry at Czervenitza, near Cashau, in Hungary, and at Gracias a Dios, in Honduras, S. A. Fire opal is brought from Zimapan, in Mexico, and from the Faroe Islands. The common opal exists abundantly in Hungary, in Faroe, Iceland, the Giants' Causeway, and the Hebrides. A very beautiful variety has been observed by the author within a half mile, and to the southwest of the watering-place at Vourla, the harbor of Smyrna. It occurs here with yellow jasper and hornstone, imbedded in a low ridge of compact limestone, of a light yellow or grayish-white color. Its colors are wax-yellow and grayish-green, occasionally white. Hungary affords also the hydrophane. The Giants' Causeway produces small masses resembling mountain cork, which, though opaque, become translucent on immersion in water. Cacholong occurs in loose masses on the river Cach, in Bucharia, whence its name. Hyalite occurs in amygdaloid at Schemnitz, in Hungary, and in clinkstone at Waltsch, in Bohemia. Menilite is found imbedded in adhesive slate, at

Menil Montant, near Paris. Wood opal forms large trees in the pumice conglomerates of Saiba, near Neusohl, and Kremnitz, in Hungary, in Faroe, and other trap countries. In Van Dieman's Land, forty miles above Hobart town, on the river Derwent, it is said to occur in large trunks. A magnificent specimen in the Liverpool Museum, from this locality, weighs between two and three hundred pounds.

Hyalite is the only variety of this species which has been discovered in the United States. It occurs in St. Lawrence Co., N. Y.; also in Burke and Scriven Cos., Georgia. At the latter place it lines cavities in a silicious shell-rock. The Suanna spring, in Florida, affords small quantities of the silicious sinter.

The precious opal, when large, and exhibiting its peculiar play of colors in perfection, is a gem of considerable value. It is cut with a convex surface. The largest mass of which we have any knowledge, is in the imperial cabinet of Vienna; it has almost the size of a man's fist, and weighs 17 ounces, but contains numerous fissures, and is not entirely disengaged from the matrix. This stone was employed as an ornament among the Greeks and Romans, and was called opalus; also *paderos*, *παιδέρως*, in allusion to its color and lustre, as expressed in the Orphic poem, *ἱμεροῦ τέρενα χρόα παιδὸς*, "having the delicate complexion of a lovely youth;"* an admirable, though poetical description of some varieties of opal.

OBSIDIAN. Hyalus Vulcani.

Empyrodox Quartz, *M.* Indivisible Quartz, Fusible Quartz, *J.* Pearlstone—Pitchstone. Pumice. Marekanite. Pechstein, Perlstein, Bimstein *of the Germans.* Petrosilex resinite. Feldspath resinite, *H.*

399. No regular forms or cleavage.

H.=6—7. G.=2·396, obsidian from Iceland; 2·212, pitchstone from Meisser. *Lustre* vitreous—pearly. *Streak* white—grayish white. *Color* black, brown, red, green, gray, white; none bright. Subtransparent—subtranslucent. *Fracture* conchoidal.

The species obsidian has been distributed into the four so called species, ***obsidian***, ***pitchstone***, ***pearlstone***, and ***pumice***. ***Obsidian*** more nearly resembles glass in its appearance, and is often called volcanic glass. ***Pitchstone*** has a resinous lustre and a splintery fracture. Its colors are principally brown, green, or red. It presents frequent transitions into obsidian on one side and pearlstone on the other. ***Pearlstone*** is a gray variety with a pearly lustre; it occurs in rounded balls, one to two inches in diameter, usually composed of thin concentric laminæ, and often containing, as a nucleus, a grain of obsidian. ***Pumice*** is a vesicular obsidian. It occasionally presents a fibrous structure, and its filaments have a peculiar silky lustre; at other times it has a more delicately glassy texture. Its vesicular structure renders it buoyant for a time on water. ***Marekanite*** is a peculiar pearl-gray translucent variety, from Marekan in Kamschatka.

Obsidian contains, according to Berthier, Thomson, and Descotils,

	Obsidian.	Pit. from Arran.	do. from Saxony.	Pearlstone.	Obsidian.
Silica	69·46	63·500	73·100	70·400	72·0
Protox. Iron	2·60	3·796	0·864	4·384	2·0
Alumina	2·60	12·736	13·560	11·600	12·5
Soda	5·08	6·220	6·320	——	10·0
Potash	7·12	——	——	5·200	—
Lime	7·54	4·260	1·484	3·000	—
Water	3·00	——	4·724	4·280	—
Magnesia	2·60	volatile, 8·000	——	——	—
	100·00, B.	98·512, T.	100·052, T.	98·864, T.	96·5, D.

These varieties fuse with more or less facility before the blowpipe, into a vesicular glass of a white or gray color.

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* Moore's Ancient Mineralogy, p. 153.

Obs. The several varieties of this species generally occur in rocks of igneous origin. They occasionally form the paste of porphyries. They have also been observed forming beds or irregular veins in sandstone. Pumice is a product of modern volcanoes.

Obsidian occurs in Iceland, the Lipari Islands, Island of Milo and other islands in the Archipelago; also at Ascension, Teneriffe, in Siberia, and Mexico. The hills around the valley of Tribisch, near Meissen, in Saxony, afford abundantly the *pitchstone* variety; at Arran, in the Isle of Man, it forms extensive beds in granite, and contains, according to Knox, 2 per cent. of bitumen. This bitumen is driven off by heat, and the pitchstone transformed into a vesicular glass. It occurs also at Newry, County Down, Irel., in smooth lamellar concretions, of a mountain or leek-green color. Pearlstone forms extensive beds in Hungary, between Tokay and Keresztur, at Glashutte, near Schemnitz, and elsewhere; also in Iceland, Spain, and Mexico. Pumice forms a hill eight hundred or one thousand feet in height, on the island of Lipari, termed from its scanty vegetation and peculiar whiteness, Il Campo Bianco. From this locality and the isles of Ponza, pumice is exported in large quantities for commerce. It occurs also in Hungary, at Teneriffe, &c., but in smaller quantities and of inferior quality. These different varieties often contain imbedded crystals of glassy feldspar, particularly those from Ischia; some obsidians occasionally include particles of olivine and traces of other volcanic minerals.

Some varieties of obsidian admit of a high polish, and have been employed for mirrors; the inhabitants of Mexico formerly made it into knives, arrowheads, and other war instruments. Some varieties present an olive-green opalescence, and are therefore valued by the lapidary. Pumice is very extensively employed for grinding and polishing, both in the solid and pulverized state. It is often a convenient filtering material.

The following species should probably be united with obsidian. It has not yet, however, been subjected to analysis.

SPHÆRULITE. HYALUS SPHÆRULUS.

400. Occurs in irregular spheroidal globules, with a rough or smooth surface; structure somewhat radiated fibrous: no cleavage.

H.=7. G.=2·416—2·452. *Lustre* pearly, inclining to resinous. *Streak* white or grayish white. *Color* various shades of brown, yellow, and gray. Subtranslucent—opaque. *Fracture* conchoidal.

Nearly infusible before the blowpipe, the edges merely becoming enamelled.

Obs. It occurs in pitchstone in round nodules, in Saxony; in radiated spheroidal globules at Glashutte, near Schemnitz, in Hungary; in roundish balls of a radiated structure, disposed in soft clay, which is evidently a decomposing rock, in the Shetland Islands, and in botryoidal masses of a bright yellow color in Brittany. Breithaupt first distinguished this species, and thus named it on account of the spheroidal shapes it commonly presents.

ISOPYRE. HYALUS FERRIFERUS.

Isopyric Quartz, *Haid.* Ed. New Phil. Jour. III. 263. Trachylite, *Breithaupt.*

401. Occurs in compact masses; no cleavage.

H.=6—6·5. G.=2·9—3. *Lustre* vitreous. *Streak* light greenish-gray. *Color* grayish or velvet black, occasionally spotted red, like heliotrope. Opaque—subtranslucent. *Fracture* flat conchoidal. Brittle. Acts slightly on the magnetic needle.

It contains, according to Dr. Turner, Silica 47·09, Alumina 13·91, Peroxyd of Iron 20·07, Lime 15·43, Oxyd of Copper 1·94=98·44.

It fuses before the blowpipe without the emission of any gaseous matter. Acids act upon it with difficulty; it is easily and completely decomposed by alkaline carbonates.

Obs. Isopyre forms compact masses, occasionally two inches in diameter, in the granite of St. Just, near Penzance, where it is associated with turmaline and tin. It much resembles obsidian, but was distinguished by Haidinger in consequence of its fainter and less vitreous lustre. Breithaupt's *trachylite* (Ed. New Phil. Jour. I. 364) appears to be identical with isopyre, it differing merely in its lower specific gravity. It occurs in small masses in basalt and wacke at Süsebühl, near Göttingen.

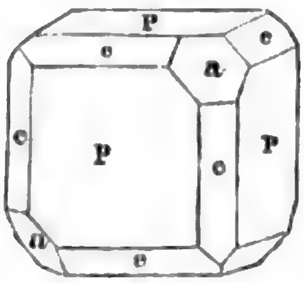
Isopyre is derived from ἴσος, *equal*, and πῦρ, *fire*, from the similarity of its comportment under the blowpipe to that of many other mineral species.

BORACITE. Boracius hemihedrus.

Tetrahedral Boracite, *M.* Octahedral Boracite, *J.* Borate of Magnesia, *P.* Biborate of Magnesia, *Thom.* Borazit, Magnésie Boratée, *H.* Calcareus Boraciten, *Wern.*

402. *Primary form:* the regular octahedron. *Secondary forms*: figs. 28 and 33, Pl. I.; also the annexed figures:

1.



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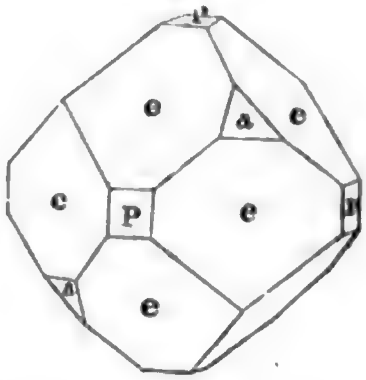


Cleavage in traces parallel to the faces of the octahedron.

H.=7. G.=2·974, Haidinger. *Lustre* vitreous, inclining to adamantine. *Streak* white. *Color* white, inclining to gray, yellow, and green. Subtransparent—translucent. *Fracture* conchoidal, uneven.

It contains, according to Stromeyer (Gilbert's Annalen, xlviii. 215) and Arfwedson, (Kong. Vet. Ac. Handl., 1822, p. 92,)

Boracic Acid	67	69·7
Magnesia	33=100, St.	30·3=100, Arf.

It intumesces before the blowpipe, and forms a glassy globule, which becomes crystalline, opaque, and white, on cooling. Heat excites four sets of electric poles, the four most highly modified angles becoming positive, and the diagonally opposite negative.

Obs. Boracite has been observed at only two localities, and in each is imbedded in gypsum, and associated with anhydrite. These localities are at Kalkberg, near Luneberg, and Segeberg, near Kiel, in the duchy of Holstein. At the former place it is also associated with common salt. It has been observed only in crystals, and these are invariably hemihedrally modified.

RHODIZITE.

G. Rose, Poggendorf's Annalen, XXXIII. 253.

403. *Primary form:* monometric. *Secondary forms:* figs. 7, 8, 9, Pl. I.

Hardness sufficient to resist the action of the knife. *Lustre* vitreous, splendent. *Color* white. Translucent.

Before the blowpipe, held in the platinum forceps, it fuses on the edges into a white opaque glass, tinging the flame at first green; then green below and red above, and finally red throughout. With borax, and salt of phosphorus, it fuses into a transparent glass, and appears to contain no silica. Dissolves with great difficulty in muriatic acid.

On account of the reactions of this species before the blowpipe, and also from its external characters, rhodizite is supposed to be closely allied to boracite.

Obs. This species was discovered by M. G. Rose, in very minute cystals on some of the red turmalines of Siberia, and was named from ῥοδίζειν, *to have the color of the rose*, in allusion to its tinging flame red.

HELVIN. Carbunculus hemihedrus.

Tetrahedral Garnet, *M.* Helvine, *Werner.*

404. *Primary form:* the octahedron. *Secondary form:* figs. 30 and 32, Pl. I. *Cleavage*, octahedral in traces.

H.=6—6·5. G.=3·1—3·3. *Lustre* vitreous, inclining to resinous. *Streak* white. *Color* wax-yellow, inclining to yellowish-brown, and siskin-green. Subtranslucent. *Fracture* uneven.

It contains, according to Gmelin, (Pogg. Annalen, iii. 55,)

Silica	33·258
Oxyd of Iron	5·564
Oxyd of Manganese	31·817
Sulphuret of Manganese	14·000
Glucina Alumina	12·029
Loss by ignition	1·155=97·823.

It fuses with effervescence in the reducing flame of the blowpipe, into an opaque globule of almost the same color as the mineral. With borax it forms a diaphanous globule, colored of an amethystine hue by manganese.

Obs. It occurs in gneiss at Schwartzenberg, in Saxony, associated with garnet, quartz, fluor, and calc spar. The only other known locality is at Hortekulle, near Modum, in Norway. It was named by Werner in allusion to its yellow color, from ἥλιος, *the sun.*

BRUCITE. Carbunculus obliquus.

Hemi-prismatic Chrysolite, *M.* Chondrodite, *Levy.* Condrodite, *H.* Maclurite, *Seybert*, (Silliman's Am. Journ. V. 336.) Fluosilicate of Magnesia.

405. *Primary form:* an oblique rhombic prism; M : M=112° 12′? Haüy. It occurs also in short prisms, with replaced angles

and edges. *Cleavage* indistinct. *Imperfect crystallizations:* structure granular; particles of various sizes.

H.=6—6·5. G.=3·118, specimen from New Jersey, Thomson; 3·199, Finland variety, Haidinger. *Lustre* vitreous—resinous. *Streak* white, or very slightly yellowish. *Color* yellow, brown, red, rarely apple-green. Transparent—subtranslucent. *Fracture* subconchoidal, uneven.

It contains, according to Seybert, (Silliman's Am. Jour. V. 336,) Thomson, (Min. i. 184,) and D'Ohsson, (Kong. Vet. Ac. Handl., 1817, p. 206,)

	New Jersey.	New Jersey.	Finland.
Silica	32·666	36·00	38·00
Fluoric Acid	4·086	3·75	—
Magnesia	54·000	54·64	54·00
Peroxyd of Iron	2·333	3·97	5·10
Potash	2·108	—	0·86
Alumina	—	—	1·50
Water	1·000=96·193, S.	1·62=99·98, T.	—=99·46, D'O.

It fuses with extreme difficulty, *per se*, before the blowpipe; it, however, loses its color and becomes opaque, and exhibits traces of fusion on the thinnest edges. With carbonate of soda, on charcoal, it fuses with difficulty into a light gray slag. With borax there is a little effervescence attending a ready fusion into a yellowish-green glass. With salt of phosphorus there is a silicious residue.

Obs. Brucite has been found only in calcareous spar. Its foreign localities are near Abö, in the parish of Pargas, in Finland, and at Aker and Gulsjö, in Sweden.

It is found in greater abundance, and greater perfection of form, in the adjoining counties of Sussex, N. J., and Orange, N. Y., where it is associated with spinel, and rarely pyroxene and bronzite.

This mineral was first described and analyzed by Count D'Ohsson, in the Memoirs of the Stockholm Academy, for 1817, p. 206. The American locality was first observed by Dr. Bruce. The name chondrodite, which it bears in foreign countries, is derived from *χονδρος, a grain*, alluding to its granular structure. Seybert's name, Maclurite, was given in compliment to Mr. Wm. Maclure, distinguished for his scientific researches, and his unbounded liberality as a patron of science.

HUMITE. Carbunculus acrotomus.

406. *Primary form:* a right rhombic prism; M : M=120°. Occurs in minute and very highly modified crystals, often presenting compound forms. *Cleavage* apparent parallel to M and $\breve{e}$, (shorter diagonal.)

H.=6·5—7. G.=3·1—3·2. *Lustre* vitreous. *Streak* white. *Color* various shades of yellow, occasionally almost white, passing into reddish-brown. Transparent—translucent. *Fracture* subconchoidal.

Before the blowpipe it becomes opaque, but is infusible. With borax it forms a transparent glass.

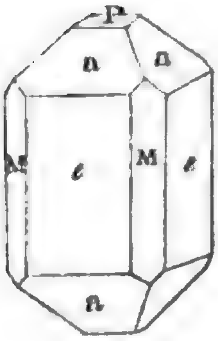
Obs. It occurs among the ejected masses of Monte Somma, associated with mica, pleonaste, and other minerals. Monticelli arranges it under Brucite.

IDOCRASE. CARBUNCULUS DIMETRICUS.

Pyramidal Garnet, *M.* Vesuvian. Egeran. Loboit, Frugardit, Idokras, *of the Germans.* Idocrase, *H.* Wiluite. Cyprine. Xanthite.

407. *Primary form :* a right square prism. *Secondary forms :* fig. 1, of a crystal from Amity, N. Y., and elsewhere ; figs. 2 and 3, of crystals from Vesuvius.

1.



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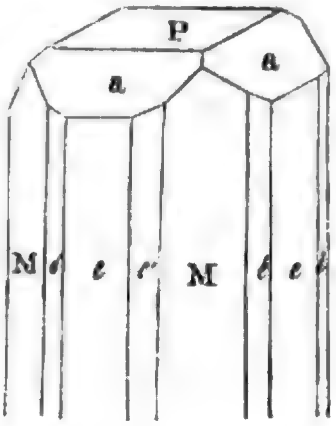

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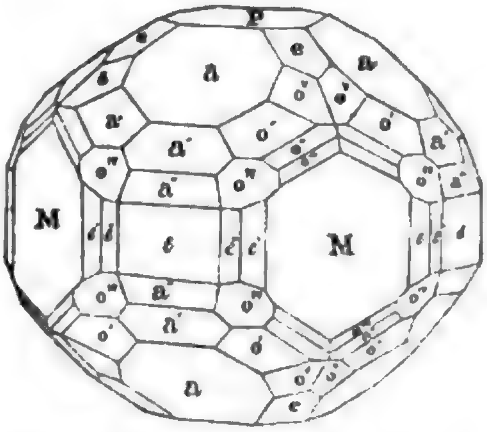


P : a=142° 53′, M : *e*=135°, M : *e*′=153° 26′, M : *e*″=161° 34′, *e* : a′=146° 33′, *e* : a″=161° 43′, a : e=154° 44½′, o^v : o^v=146° 25′, o′ : o′=139° 54′, o″ : o″=134° 45′, P : e=151° 56′. *Cleavage* parallel with M not very distinct, still less distinct parallel with P. *Imperfect crystallizations :* columnar structure rare—particles straight and divergent, or irregular ; occasionally granularly massive.

H.=6·5. G.=3·349—3·399. *Lustre* vitreous ; often inclining to resinous. *Streak* white. *Color* brown, passing into various shades of green ; green colors frequently bright and clear ; occasionally sulphur-yellow. In some varieties, the color appears oil-green in the direction of the axis, and pistachio-green at right angles with it. Subtransparent—faintly translucent. *Fracture* subconchoidal—uneven.

It contains, according to Magnus, (Pogg. Annalen, xxi. 50,)

	Vesuvius.	Slatoust.	The Bannat.
Silica	37·359	37·178	38·519
Alumina	23·530	18·107	20·063
Protoxyd of Iron	3·992	4·671	3·420
Lime	29·681	35·791	32·411
Magnesia	5·208	0·773	2·987
Protox. Mang.	=99·77	1·495=98·015.	0·018=97·418.

It is consequently composed of equal parts of silicate of alumina and silicate of lime. In the blowpipe flame it fuses with some effervescence into a translucent yellow globule, and forms, with borax, a diaphanous glass, tinged by iron.

Obs. Idocrase was first discovered in the ancient Vesuvian lavas, and was thence called Vesuvian. It has since been discovered in serpentine, gneiss, and primitive limestone. The Vesuvian idocrase is of a hair-brown or an olive-green color, and is asociated with ice spar, garnet, mica, and nepheline. The crystals are commonly small; several have been found, however, which exceed an inch in each direction. The finest specimens occur at Ala, in the Val di Brozzo, in Piedmont; they are usually subtransparent, of brilliant lustre, and have green or brown colors; rarely perfectly black. Egge, near Christians and in Norway; Wilui river, Lake Baikal; Monzoni, in the Fassa valley, are other localities. Crystals of a sulphur-yellow color have been found at the latter place. Liver-brown diverging groups, are brought from Eger, in Bohemia, whence the name *Egeran*, for specimens of this species. Crystals of a blue tint, called *cyprine*, have been described by Berzelius, from the vicinity of Tellemarken, in Norway. The color is supposed to be owing to the presence of a minute portion of copper.

At Worcester, Mass., idocrase occurs similar to the Egeran variety, forming seams and veins in a quartzose rock; it is here associated with pyroxene and garnet. It also occurs at Amity, N. Y., both granular and in crystals, disseminated through limestone, with pyroxene and hornblende; the crystals are occasionally an inch in diameter.

Idocrase is derived from *εἰδῶ*, *I see*, and *κρᾶσις*, *mixture*; because its crystalline forms have much resemblance to that of several other species.

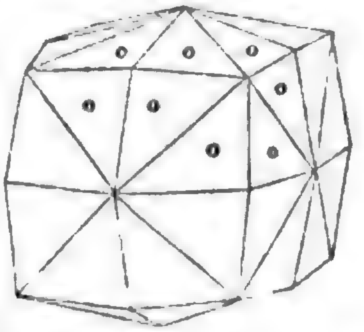
The species xanthite (*Thomson*, Ann. of N. Y. Lyceum; *Mather*, Silliman's Journ. xviii. 359) is closely similar in composition to idocrase. The following is its composition, as obtained by Thomson:

Sillca	37·708	35·092
Lime	36·308	33·080
Alumina	12·280	17·428
Peroxyd of Iron	12·000	6·368
Protoxyd of Manganese	3·680	2·801
Magnesia	——	2·001
Water	0·600=102·576.	1·680=98·450.

The second analysis is stated by Thomson to have been performed on the purer specimen. According to Mather, however, it exhibits cleavages parallel to the faces of an oblique rhomboidal prism of the following angles: 97° 30′; 94°; 107° 30′. It usually consists of a congeries of very small rounded grains, of a grayish-yellow color, easily separable, and thus presenting low degrees of hardness. Specific gravity 3·201—3·221, Thomson. With borax it forms a glass, which is yellow while hot, but becomes colorless on cooling.

GARNET. CARBUNCULUS DODECAHEDRUS.

Dodecahedral Garnet, *M.* and *J.* Melanite. Pyrope. Grossularite. Topazolite. Almandine. Aplome. Essonite, Cinnamon stone. Greenlandite. Pyrenaite. Colophonite. Allochroite. Granat. Pirop. Kolophonit. Romanzovit, *Nordenskiöld.* Braunsteinkiesel, *W.* Grenat, *H.* Carbunculus.



408. *Primary form:* the rhombic dodecahedron. *Secondary forms:* Pl. I., figs. 11, 16, 18, 27; also several of these in combination; also the annexed figure, which is similar to fig. 25, a hexoctahedron. *Cleavage* indistinct parallel with the faces of the dodecahedron. Planes E often striated parallel to their common intersections, and occasionally parallel to the faces of the cube, (P, fig. 6, Pl. I.) *Imperfect crystallizations:* structure lamellar—laminæ thick and bent; structure granular—particles of various sizes, sometimes impalpable; strongly coherent—friable.

H.=6·5—7·5. G.=3·5—4·3. *Lustre* vitreous—resinous. *Streak* white. *Color* red, brown, yellow, white, green, black; none bright, except some red colors. Transparent—subtranslucent. *Fracture* subconchoidal, uneven.

The several varieties of this species are quite different in their composition. They all contain Silicate of Alumina, and variable proportions of the Silicates of Lime, Iron, or Manganese, which substances have the property of replacing one another without causing a change of crystalline form. These varieties have often been classed as distinct species, and, therefore, require some particular explanations.

Garnet includes the red and brownish-red specimens; these have been called *precious* or *common*, according as they were nearly transparent or opaque. The precious garnet is again divided into *Almandine* and *pyrope*, according to its transparency. The pyrope is described as presenting a dark blood-red color by reflected light, but yellow by transmitted. *Pyrope* was so called from *πυρ*, *fire*, *οπτομαι*, *to see*, in allusion to its color.

Cinnamon stone, *essonite* or *canehlstein* of the Germans, is intermediate in its color between hyacinth-red and orange-yellow, and was called by the first and last of the above names, because of its resemblance to the color of cinnamon. *Colophonite* is composed of coarse roundish particles easily separated, presenting reddish-brown, yellowish-brown, oil-green, and honey-yellow colors, and often a fine iridescence. When the particles are impalpable and strongly coherent, it is called *allochroite*. *Melanite* (from *μελας*, *black*) occurs in black dodecahedrons, sometimes modified. *Pyrenaite* is found in minute black symmetrical dodecahedrons, and was so called from its locality in the Pyrenees, at the Pic Eres Lids, near Barèges. *Grossular* or grossularite, has a pale gooseberry green color, (whence its name,) and invariably has the form of fig. 16, Pl. I. *Topazolite* occurs in small yellow crystals. *Aplome* presents the form of the dodecahedron, but the faces are striated parallel to the shorter diagonal; its color is brown, sometimes greenish. G.=3·44, otherwise it resembles garnet. *Romanzovite* of Nordenskiöld, from Kimito, in Finland, is apparently a variety of cinnamon stone.

The composition of these varieties has been determined as follows:—

	Prec. Garnet.	Essonite.	Melanite.	Grossular.
Silica	35·75	39·826	42·450	40·55
Alumina	27·25	20·141	22·475	20·10
Lime	——	30·574	6·525	34·86
Oxyd of Iron	36·00	9·459	9·292	5·00
Magnesia	——	——	13·430	——
Oxyd of Mang.	0·25	——	6·273	0·48
	99·25, Klap.	100·000, Leh.	100·445, Wachtmeister.	100·99, Do.

	Pyrope.	Colophonite.	Allochroite.	Pyrenaite.
Silica	43·70	37·0	35·0	43
Alumina	22·40	13·5	8·0	16
Lime	6·72	29·0	30·0	20
Oxyd of Iron	11·48	7·5	17·0	16
Magnesia	5·60	6·5	—	—
Oxyd of Mang.	3·68	4·8	3·5	Water 4
	93·58, Kobell,	98·3, Simon.	93·5, Vauq.	99, Vauq.

Pyrope contains, in addition, 7·68 per cent. of chromic acid.

These several varieties fuse with some difference of facility into a black vitreous globule, which often acts on the magnet.

Obs. Garnet occurs imbeded in mica slate, granite, and gneiss, and occasionally in limestone, chlorite slate, serpentine, and lava. The precious garnet occurs in the greatest perfection in Ceylon and Greenland. Common garnet is met with in dodecahedrons from three to four inches in diameter, at Fahlun, in Sweden, Arendal and Kongsberg, in Norway, and the Zillerthal. It occurs abundantly in crystals of less size, in mica slate, in the island of Mull, the shires of Perth and Inverness, Shetland. Green crystals are met with at Schwartzenberg, in Saxony. Melanite is found in the Vesuvian lavas, and also near Rome. *Grossularite* occurs near the Wilui River, in Siberia. *Cinnamon stone* is met with in masses of considerable size in the primitive rocks of Ceylon. *Aplome* occurs on the banks of the river Lena in Siberia, and at Schwartzenberg, in Saxony.

Several beautiful varieties of this species occur in the United States. Hanover, N. H., affords small but beautifully symmetrical crystals, transparent, and of a rich brownish-red color; they are there disseminated in hornblende gneiss. Dark blood-red, and highly splendent dodecahedrons, with beveled and truncated edges, occur at Franconia, N. H., in geodes, in massive garnet, calcareous spar, and magnetic iron ore. At Carlisle, Mass., beautiful geodes of crystals, of a transparent, cinnamon-brown color, similar to fig. 18, Pl. I., accompany scapolite in white limestone; Boxborough, in the same region, affords similar but less remarkable specimens. Crystals of melanite, sometimes an inch in diameter and of rare beauty, occur in geodes at Franklin furnace, in New Jersey, in limestone, associated with quartz and greenish feldspar. At Monroe, Conn., are obtained very perfect and highly lustrous trapezohedral crystals, from a half to one inch in diameter, imbedded in mica slate. Haddam affords large but brittle and irregular trapezohedrons, associated with chrysoberyl, beryl, automolite, and Columbite. Large dodecahedral crystals, sometimes two inches or more in diameter, of a dark brownish-red color, are found at New Fane and Marlborough, Vt., in chlorite slate; also in mica slate, in Chesterfield, Mass. The limestone, at Lyme, Conn., affords a blackish-brown variety in large crystals, similar to fig 18, Pl. I. *Colophonite*, composed of large particles, constitutes a powerful vein in gneiss, at Willsborough, N. Y., on Lake Champlain. A finer grained variety, of yellow and red colors, is met with on Roger's Rock, Lake George. Compact garnet occurs at Franconia, N. H. Yellow and reddish-brown varieties occur with Franklinite, at Franklin furnace, N. J., in limestone.

Pyrope is often highly esteemed as a gem. The cinnamon stone from Ceylon is also highly prized, when large, finely colored, and transparent. Pulverized garnet is sometimes employed as a substitute for emery.

The garnet was, in part, the carbunculus of the ancients. This term was probably applied also to the spinel and Oriental ruby. The Alabandic carbuncles of Pliny were so called because cut and polished at Alabanda.* Hence the name Almandine, now in use. Pliny describes vessels of the capacity of a pint, formed from carbuncles, "non claros ac plerumque sordidos ac semper fulgoris horridi," devoid of lustre and beauty of color, which probably were large common garnets. The garnet is also supposed to have been the hyacinth of the ancients.

A mineral has been lately described by M. Hess, of St. Petersburg, under the name of *Ouwarowite*, which bears a very close resemblance to the green garnet. It occurs in transparent emerald-green dodecahedrons, having a hardness of 7·5. When heated it does not give out water, nor decrepitate, nor change its color. With borax it fuses with difficulty into a clear chrome-green glass. With salt of phosphorus it is decomposed only when in powder; the bead, when cold, has a fine green color, and is muddy from interspersed silica. It appears to be of more difficult fusion than the garnet, and also to have a superior hardness. It occurs at Bissersk, Russia.

ZIRCON. CARBUNCULUS QUADRATUS.

Prismatic Zircon, *M* and *J.* Hyacinth. Jargon. Zirconite. Silicate of Zirconia. Zirkon.

409. *Primary form:* a right square prism. *Secondary forms:* The first, and the second excepting the planes o′, occur as modifications of the zircon of Buncombe Co., N. C. Fig. 2, with the terminal edges of the pyramid truncated, occurs at Middlebury, Vt.

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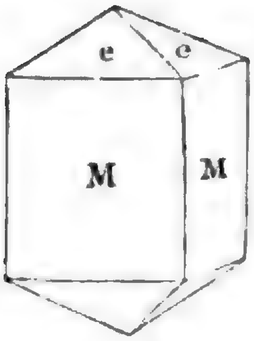
* Moore's An. Min. p. 156.

1.



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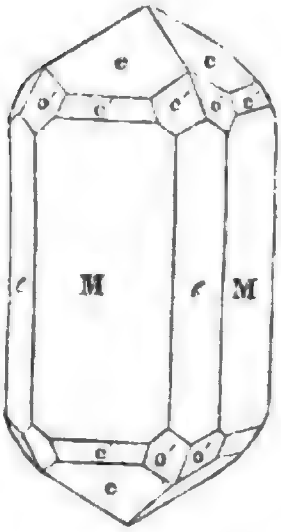

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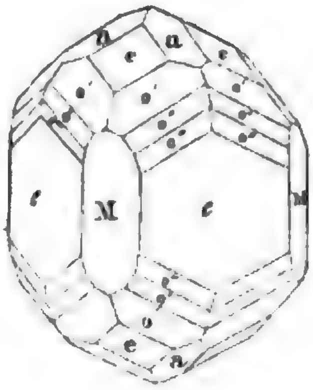

Fig. 3 represents a crystal from the Sau Alpe; M : *e*=135°, M : e=132° 10′, e : e=123° 19′, M : e′=159° 47′, o′ : o′=147° 3′, a : *e* =122° 39′, a : e=151° 39′. *Cleavage* parallel to M; also less distinct parallel to e. It occurs also in irregular forms and grains.

H.=7·5. G.=4·5—4·75; 4·505, Haidinger; 4·681, Thomson; 4·721, Lowry; 4·453, a crystal from Buncombe Co., N. C., Vanuxem. *Lustre* more or less perfectly adamantine. *Streak* white. *Color* red, brown, yellow, gray, white. Transparent—subtranslucent. *Fracture* conchoidal, and brilliant.

It contains, according to Vauquelin, Muir, Berzelius, and Vanuxem,*

	Ceylon.			North Carolina.
Silica	31	33·32	33·48	32·08
Zirconia	66	66·00	67·16	67·07
Oxyd of Iron	2	trace	—	—
	99, Vau.	99·32, Muir.	100·64, Berz.	99·15, Van.

It loses its color, but is infusible, *per se*, and also with carbonate of soda and salt of phosphorus. With borax it melts into a diaphanous glass.

Hyacinth includes those individuals which present bright colors, considerable transparency, and whose crystals have smooth and shining surfaces. *Zirconite* presents grayish or brownish tints, and is frequently rough and opaque. The variety from Ceylon, which is colorless, or has a smoky tinge, and is therefore sold for inferior diamonds, is sometimes called *jargon*.

Hyacinth occurs in the sand and alluvial deposits of certain rivers in Ceylon, at Expaillie, near Puy de France; at Ohlapian, in Transylvania; occasionally in volcanic tufa in Auvergne, and at Vesuvius. Siberia affords crystals as large as walnuts. Splendid specimens occur also in Greenland, and in the zircon-sienite of Frederickswarn, in Norway.

In Buncombe Co., N. C., on the road leading from the Saluda Gap to Ashville, upon the first elevation, after passing Green river, very beautiful crystals of zircon are found loose in the soil, and sometimes attached to feldspar and quartz. Fine specimens occur at Warwick, N. J., in gneiss; at Monroe, in magnetic iron ore; and at Edenville, in scapolite. Specimens have also been obtained near Trenton, New Jersey, in gneiss. Loose masses of sienite at Middlebury, Vt., have afforded some specimens; also the talcose slate at Easton, Penn. The chrysoberyl locality at Haddam has yielded some small but very perfect crystals.

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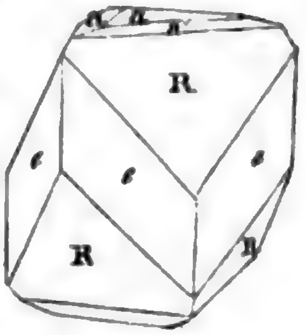
* Journal of the Acad. of Nat. Sci. of Philad., III. 59.

Hyacinth rarely occurs of sufficient dimensions to be valued as a gem.

It is very doubtful whether the modern hyacinth is one of the number of stones that were called hyacinth (υακινθος) by the ancients. Jameson seems to have supposed that they applied this name to the amethyst or sapphire.

EUDIALYTE. CARBUNCULUS RHOMBOHEDRUS.

Rhombohedral Almandine-Spar, *Haid.* Eudyalite, *improper orthography.*



410. *Primary form:* an acute rhombohedron; R : R=73° 40′, and 106° 20′. *Secondary form:* R : *e*=143° 10′. R : a=112° 33′, R : a′=143° 44′. a : *e*=90°. *Cleavage* parallel with a, very perfect. Occurs very massive.

H.=6. G.=2·9036. *Lustre* vitreous. *Streak* white. *Color* brownish-red, rose-red. Opaque—slightly translucent. *Fracture* subconchoidal or splintery.

Stromeyer obtained in two analyses, (Untersuchungen, p. 438,)

Silica	52·47	53·325
Zirconia	10·89	11·102
Lime	10·14	9·785
Soda	13·92	13·822
Protoxyd of Iron	6·85	6·754
Protoxyd of Manganese	2·57	2·062
Muriatic Acid	1·03	1·034
Water	1·80=99·67.	1·801=99·685.

It fuses before the blowpipe into a leek-green scoria. When pulverized it gelatinizes with acids.

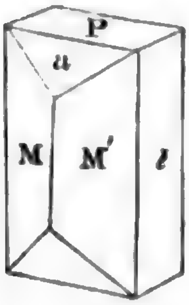
Obs. The only known locality is at Kangerdluarsuk, in West Greenland, where it is either associated with hornblende and sodalite, or imbedded in compact white feldspar. The crystals are usually small, but sometimes occur an inch or more in length. It was first described by Stromeyer, who gave it the above name on account of its easy solubility in acids, from ευ, *easily*, and διαλυω, *to dissolve.*

STAUROTIDE. CARBUNCULUS DECUSSATUS.

Prismatoidal Garnet, *M.* Grenatite. Staurotide, *H.* Staurolith, *W.*

411. *Primary form:* a right rhombic prism; M : M=129° 31′. *Secondary forms:*

1.



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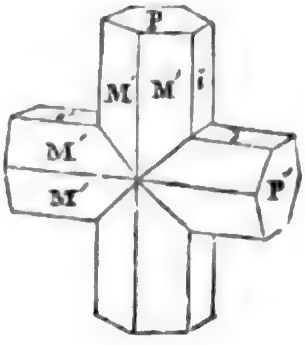

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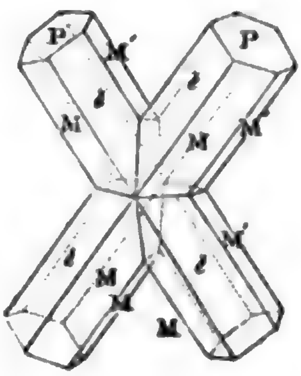


P : a=125° 16′, M : ĕ=115° 15′. *Cleavage* parallel to ĕ, but interrupted; parallel to M less distinct. Surface P, often quite rough and concave. *Compound crystals:* fig. 3 has proceeded from a nucleus composed of four molecules, and is an example of composition parallel to a plane e, on a terminal edge. Fig. 2 represents a compound crystal, in which composition is of the *third* kind, and parallel to a plane on the acute solid angles. This peculiar position has arisen from the concurrent action of four molecules. (See §§ 76, 77.) These forms are of very common occurrence. *Imperfect crystallizations* have not been observed.

H.=7—7·5. G.=3·693, Thomson; 3·724, Haidinger; 3·273, an opaque and impure specimen, Thomson. *Lustre* subvitreous, inclining to resinous. *Streak* white, or grayish-white. *Color* dark reddish-brown—brownish-black. Translucent—nearly or quite opaque. *Fracture* conchoidal.

It contains, according to Klaproth, Thomson, and Vauquelin,

			Brittany.
Silica	37·50	36·696	33·00
Alumina	41·00	39·880	44·00
Protoxyd of Iron	18·25	18·144	13·00
Protoxyd of Manganese	0·50	4·046	1·00
Magnesia	0·50	0·686	Lime 3·84
Moisture	——	0·080	——
	97·75, Klap.	99·532, Thom.	94·84, Vauq.

Before the blowpipe it darkens, but does not fuse.

Obs. It occurs imbedded in mica slate and gneiss, at St. Gothard, in Switzerland, and the Greiner mountain, Tyrol, affords simple crystals of this species, associated with kyanite. Their connection with kyanite is sometimes very peculiar: they occur, apparently, as a continuation of its crystals, and also parallel with them. It has been stated (§ 79) that there is a kind of crystallogenic induction, which influences the relative position of crystals of the same substance, and often causes them to unite in the formation of postnatal twins. This appears to be an instance of a similar influence between the crystallogenic attraction of different substances. Twin crystals of a large size, occur in Bretagne; also at Oporto and St. Jago de Compostella, &c.

Staurotide is very abundant throughout the mica slate of New England. Franconia, Vt., affords large brownish-red opaque crystals, often presenting compound forms; also a brownish-black variety. Chesterfield, Mass., Hartwell and Winthrop, Me., Bolton and Tolland, Conn., and New York, 3½ miles from the city, are other localities. It also occurs abundantly, in single crystals, of a dark reddish-brown color, on the Wichichon, about 8 miles from Philadelphia.

Staurolite is so called from σταυρος, *a cross*, and λιθος, *stone*.

OSTRANITE. Carbunculus rhombicus.

Breithaupt, Edin. New Phil. Jour. IV. 186.

412. *Primary form:* a right rhombic prism; M : M=96° and 84°. *Secondary form:* similar to fig. 2 of Zircon; e : e=128° 14′, and 133° 42′. *Cleavage* parallel with ĕ, (shorter diagonal,) scarcely perceptible.

H.=7—8. G.=4·32—4·4. *Lustre* vitreous. *Color* clove-brown. Very brittle.

It does not fuse before the blowpipe, but its color becomes paler. With borax, it melts with difficulty into a transparent glass. It is insoluble in nitric acid.

Obs. This mineral occurs in Norway, and it is supposed in the zircon-sienite of Fredrickswarn. It resembles zircon, but differs in crystallization.

ORDER VII. SCAPTINEA.

RED ZINC ORE. Rutilus Brucii.

Prismatic Zinc Ore, *M.* Red Zinc, Red Oxyd of Zinc. Manganesian Oxyd of Zinc. Zinkoxyd, *L.* Zinc Oxydé Ferrifère Brun Rougeatre, *H.*

413. *Primary form:* a right rhombic prism; foliated parallel to the base of the prism. *Imperfect crystallizations:* structure foliated; granular—particles strongly coherent.

H.=4—4·5. G.=5·432—5·523. *Lustre* subadamantine. *Streak* orange-yellow. *Color* deep red, also inclining to yellow. Translucent—subtranslucent. *Fracture* subconchoidal. Brittle.

It contains, according to Berthier, Oxyd of Zinc 88, and Sesquoxyd of Manganese 12. It is infusible, *per se*, before the blowpipe; with borax it yields a yellow transparent glass. It dissolves without effervescence in nitric acid. On exposure to the air, it suffers a partial decomposition at the surface, and becomes invested with a white coating, which is carbonate of zinc.

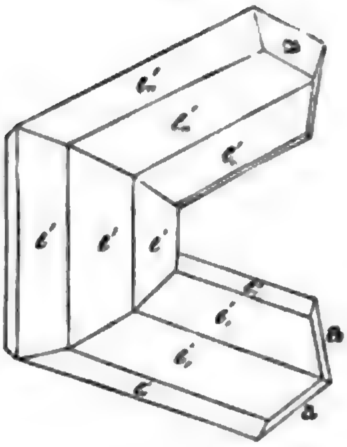
Obs. It occurs with Franklinite, and also with calcareous spar, at Franklin and Sterling, N. J. It was first noticed, described, and analyzed, by Dr. Bruce, (Bruce's American Mineralog. Journ., vol. i. p. 96.) Mitscherlich has observed some minute six sided prisms, in the iron furnaces of Konigshutte, in Silesia, which he believes to be identical with this species.

RUTILE. Rutilus quadratus.

Peritomous Titanium Ore, *M.* Titanite. Nigrine. Crispite. Gallizinite. Sagenite, *Saussure.* Titane Oxydé, *H.* Titanic Acid, *Thom.*

414. *Primary form:* a right square prism. *Secondary forms:* fig. 51, Pl. I, with the planes a, so extended as to form a four sided pyramid at each extremity of the crystal. Also the annexed figures:

1.



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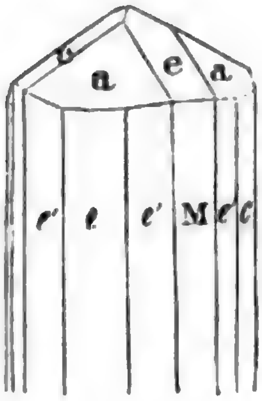


M : *e*=135°, M : *e′*=161° 34′, *e* : *e′*=153° 26′, a : a=117° 2′, a : e= 148° 31′, M : e=123° 59′, e : e=128° 41′. *Cleavage* parallel to M distinct; to *e* less so. M, *e* and *e′*, are usually vertically striated. Crystals often acicular. *Compound crystals:* they occur under the form of singly and doubly geniculated crystals; one of the latter kind is represented in fig. 1. For an explanation of these forms, see § 78. *Imperfect crystallizations:* structure granular, particles of various sizes, and strongly coherent.

H.=6—6·5. G.=4·18, Klaproth; 4·249, Mohs; a dark variety from Ohlapian. *Lustre* metallic adamantine. *Streak* very pale brown. *Color* reddish-brown, passing into red; sometimes yellowish. Subtransparent—opaque. *Fracture* subconchoidal, uneven. Brittle.

If pure titanic acid, it is composed of Titanium 66·05, and Oxygen 33·95; but Nigrine contains about 14 per cent. of Oxyd of Iron. Before the blowpipe it remains unaltered. With borax it forms a hyacinth-red bead. It communicates a pale-red color to salt of phosphorus, but does not fuse with it.

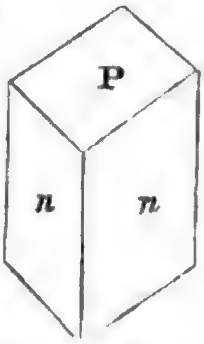
Obs. Rutile is generally found in imbedded crystals, in masses of quartz or feldspar, and often occurs in acicular crystals, penetrating quartz crystals. It has also been met with on specular iron. In this situation it occurs in the Grisons. Brazil affords the acicular crystallizations in limpid quartz. At Yrieix, in France, and in Castile, geniculated crystals are obtained, often of large size. At Ohlapian, in Transylvania, it is found in pebbles, of a black color, and hence called Nigrine. A massive variety occurs at Arendal, in Norway; also at Karingbricka, in Sweden; the latter is said to contain 3 per cent. of chrome, and is the *Titane oxidé chromifère* of Haüy. At Windsor, Mass., crystallized rutile occurs thickly disseminated through narrow veins of feldspar, traversing an extensive ledge of chlorite slate. Large compound crystals, of a dark color, are occasionally found at Lane's Mine, Monroe, Conn., also in the neighboring town of Huntington. The mica slate of Hampshire, Berkshire, and Franklin counties, Mass., contains this species, but no where in considerable quantity. It occurs in beautiful translucent and subtranslucent crystals, in a feldspar quarry near Middletown. It is met with in small brilliant crystals, in white limestone, with spinel, serpentine, talc, mica, &c., at Amity, N. Y., and with blue sapphire, turmaline, and spinel, in a similar rock at Newton, N. J. Loose crystals have been found in North Carolina and Virginia.

The finer specimens of this species from Middletown, Conn., when cut and polished, form a gem of rare beauty. The oxyd of titanium is employed in painting porcelain.

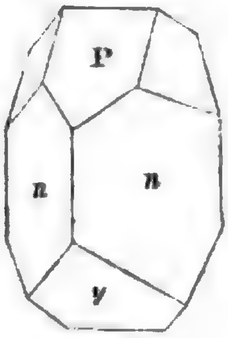
Rutile is so named, in allusion to its color, from the Latin rutilus, which signifies both *red* and *resplendent*. Saussure named a reticulated variety *sagenite*, from σαγηνη, *a net*.

SPHENE. Rutilus obliquus.

Hemi-prismatic Titanium Ore, *M.* Titanite. Braun-Menakerz, Gelb Menacherz, Menachine Ore, *Wern.* Sphène Titane Silico calcaire, *H.*



Norway,—Roger's Rock, Lake George.



Gouverneur, N. Y.

415. *Primary form:* an oblique rhombic prism. *Secondary forms:* $n : n$=136° 8′, P : y (adjacent planes) =60° 24. *Cleavage* parallal to n and P; not easily obtained. *Imperfect crystallizations:* lamellar and granular structure; particles in the latter strongly coherent.

H.=5—5·5. G.=3·468, Haidinger. 3·2378, of a specimen from St. Gothard, Cordier. *Lustre* adamantine—resinous. *Streak* white. *Color* brown, gray, yellow, green, and sometimes black. Transparent—opaque. Brittle.

It contains, according to Klaproth, (Beitrage i. 251,) and Cordier, (Jour. des Mines, xiii. 70,)

Silica	35	28·0
Titanic Acid	33	33·3
Lime	33=101, K.	32·2=93·5, C.

Before the blowpipe the yellow varieties are not altered in color; the others become yellow. They slightly intumesce, and fuse on the edges into a dark enamel. With borax they afford a yellowish-green glass. They dissolve in heated nitric acid, with the exception of a silicious residue.

Obs. This species was formerly divided into *titanite* and *sphene*, the former included the brown or black varieties, the latter the lighter colored and translucent.

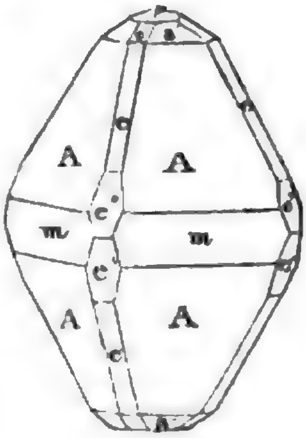
Sphene occurs interspersed among primary rocks, in gneiss, granite, mica slate, primitive limestone; also in sienite, and beds of iron ore. Titanite occurs with pyroxene, in beds of iron ore, at Arendal, in Norway, in granite at Sartut, in Greenland. Sphene in complicated compound crystals, of a pale green color and transparant, occurs at Graubinden, in the Grisons, associated with feldspar and chlorite, on mica slate at St. Gothard; also at Mont Blanc, and elsewhere, in the Alps. Small crystals occur in sienite at Strontian, in Argyleshire, and Criffle, in Galloway. Occasionally it is found among volcanic rocks, as at the Laachar See, and Andernach on the Rhine.

In Canada, at Grenville, and in Bucks Co. Penn., three miles west of Attleboro', it is associated with tabular spar and plumbago. At Roger's Rock, on Lake George, it occurs very abundantly in small brown crystals, disseminated through an aggregate of feldspar and pyroxene. A similar variety occurs both crystallized and massive, at Bolton, Mass., in limestone, accompanied with pyroxene and petalite. In small black shining crystals it is met with at Gouverneur, N. Y., imbedded in primitive limestone and associated with apatite and scapolite. It occurs also in rounded grains and imperfect crystals disseminated through limestone with hornblende, &c., at Edenville and Amity, N. Y., and at Trumbull, Conn.

The name *sphene* was applied to this mineral in allusion to the form of the crystal, from σφην, *a wedge*.

ANATASE. Rutilus pyramidalis.

Pyramidal Titanium-Ore, *M.* Octahedrite, *J.* Oisanite. Titane Anatase, *H.*



416. *Primary form:* a square octahedron; A : A (in the same pyramid) =97° 56′, A : A (adjacent, but in different pyramids) =126° 22′. *Secondary form:* A : e=138° 58′, A : m=153° 11′, A : p=116° 49′, a : m=116° 33′, e″ : e″= 148° 23′. *Cleavage* parallel to A and *p*, perfect.

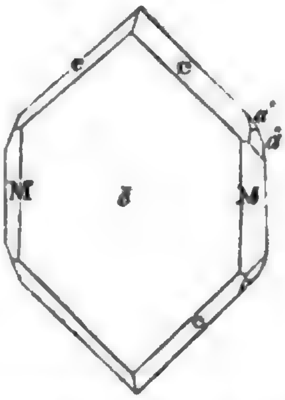
H.=5·5—6. G.=3·857, Haüy; 3·826, Mohs. *Lustre* metallic-adamantine. *Streak* white. *Color* various shades of brown, passing into indigo-blue; greenish-yellow by transmitted light. *Fracture* subconchoidal, scarcely observable.

According to Vauquelin, it is a pure Oxyd of Titanium, and before the blowpipe exhibits the phenomena of that substance. When heated it gives out a reddish-yellow phosphorescent light, which appears suddenly like a flame and is soon over; a peculiarity, according to Sir D. Brewster, not met with in any other species.

Obs. Anatase occurs most abundantly at Bourg d' Oisans, in Dauphiny, accompanying feldspar, axinite, and Crichtonite. It is also found in mica slate in the Grisons; at Tavatsch, in the Tyrol. In Brazil it occurs both imbedded in quartz and in detached crystals of so splendent lustre, as to be sometimes mistaken for diamonds.

BROOKITE. Rutilus Brookianus.

Prismatic Titanium-Ore, *Haid.* Jurinite, *Soret.* Brookite, *Levy.*



417. *Primary form:* a right rhombic prism; M : M=100°. *Secondary form:* M : ē=140°, e : e=101° 37′. *Cleavage* parallel to M indistinct; parallel to P still more so.

H.=5·5—6. *Lustre* metallic-adamantine. *Streak* yellowish-white. *Color* hair-brown, passing into deep orange-yellow and some reddish tints. Translucent—opaque. Brittle.

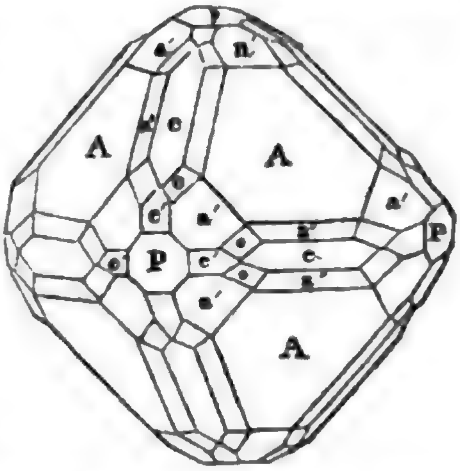
It contains Oxyd of Titanium, with traces of Oxyd of Iron and Manganese, but has not yet been analyzed.

Obs. Brookite was first observed among some minerals accompanying titanite from Dauphiny, by Mr. Soret, of Geneva. It has since been discovered in finer crystals at Snowdon, Wales. It was named by Mr. Levy, in honor of Mr. Brooke.

RED COPPER ORE. Rutilus octahedrus.

Octahedral Copper Ore, *M*. Red Oxyd of Copper. Oxydulated Copper, *P*. Tile Ore. Rothkupfererz, Ziegelerz, *W*. Cuivre Oxidé Rouge, Cuivre Oxidulé, *H*.

418. *Primary form:* the regular octahedron. *Secondary forms:* figs. 2, 3, 5, 6, 7, 8, 9, 10, 11, &c., Pl. I., also several of these forms in combination, as in the annexed figure. *Cleavage* parallel to A. *Imperfect crystallizations:* structure granular; particles of various sizes occasionally impalpable. Sometimes earthy.



H.=3·5.—4. G.=5·992, Haidinger. *Lustre* adamantine, or submetallic—earthy. *Streak* several shades of brownish-red. *Color* red, of various shades, particularly cochineal-red; occasionally crimson-red by transmitted light. Subtransparent—subtranslucent. *Fracture* conchoidal, uneven. Brittle.

It contains Copper 88·88, (two atoms,) and Oxygen 11·12, (one atom.) Before the blowpipe, in the reducing flame, on charcoal, it affords a globule of copper. It dissolves with effervescence in nitric acid.

Obs. *Tile ore* formerly included the earthy varieties. These usually present a brick-red, or reddish-brown color, and are frequently mixed with oxyd of iron. They occur in the Bannat, at Camsdorf and Saalfield, in Thuringia, and in Cornwall. Fine translucent crystals of red copper ore occur with native copper and quartz at Wheal Gorland, and other Cornish mines. Isolated crystals, sometimes an inch in diameter, are found imbedded in lithomarge at Chessy, near Lyons: they are generally coated with malachite. Splendid specimens are brought from the Bannat and Ekatherinenberg, in Siberia. Cornwall and Rheinbreibach, on the Rhine, affords the *capillary* variety, which occurs in extremely slender crystals, reticularly and confusedly aggregated, often appearing fibrous and flocculent.

It has been observed massive at Schuyler's mine, N. J., associated with chrysocolla and native copper.

When found in large quantities, this species is valuable as an ore of copper.

PYROCHLORE. Rutilus dystomus.

Octahedral Titanium-Ore, *M*. Pyrochlore, *Brewster's* Journ. VI. 358.

419. *Primary form:* the regular octahedron. *Cleavage* none. H.=5. G.=4·2—4·25. *Lustre* vitreous or resinous. *Streak* pale brown. *Color* dark reddish-brown; the fresh fracture almost black. Faintly subtranslucent—opaque. *Fracture* conchoidal.

It contains, according to Wöhler, Titanic Acid 62·75, Lime 12·85, Protoxyd of Uranium 5·18, Oxyd of Cerium 6·80, Protoxyd of Manganese 2·75, Oxyd of Tin 0·61, Oxyd of Iron 2·16, and Water 4·20=97·30; also a trace of fluoric acid and magnesia.

Before the blowpipe it becomes pale brownish-yellow, but retains its lustre, and with great difficulty fuses into a blackish-brown scoria. It is perfectly dissolved in borax, affording a reddish-yellow transparent globule in the oxydating flame, which, on flaming, becomes opaque. When a considerable portion of the assay is added, the glass on cooling assumes the form of a white enamel. In salt of phosphorus it dissolves completely, and at first with some effervescence. The glass in the oxydizing flame is yellow while hot, but becomes grass-green on cooling.

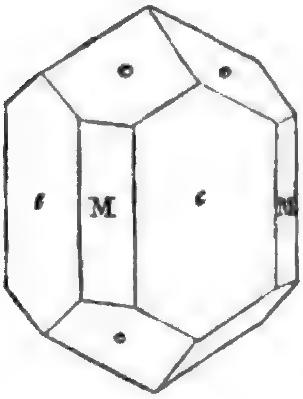
Obs. It occurs imbedded in sienite at Fredrickswarn and Laurvig, in Norway, associated with zircon, to which it has considerable resemblance; and also polymignite and phosphate of yttria. It was named by Berzelius in allusion to its property of becoming yellowish-green under the blowpipe, from πυρ, *fire*, and χλωρος, *green*.

TIN ORE. Jovius quadratus.

Pyramidal Tin-Ore, *M*. Oxyd of Tin. Peroxyd of Tin, *Thom*. Tin Stone. Wood Tin. Stream Tin. Kornisch Zinerz, Zinstein, *W*. Etain Oxydé, *H*.

420. *Primary form:* a right square prism. *Secondary forms:*

1.



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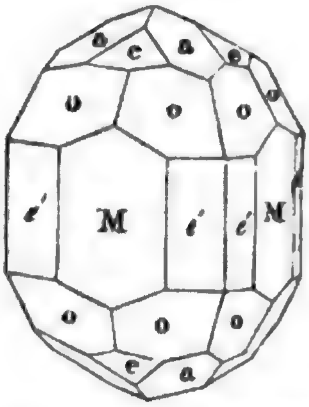


figs. 1 and 2, of crystals from Cornwall. M : e=133° 38′, e : e=121° 35′, *e* : a=124°, e : a=150° 47′, o : o=159° 6′ and 118° 16′, *e′* : *e′*=112° 37′ and 157° 23′. *Cleavage* indistinct parallel with M and *e*. *Compound crystals:* fig. 2, p. 43, composition of the *third kind*, or parallel to the plane a; fig. 12, Pl. IV., composition of the third kind; effected subsequent to the commencement of the formation of the crystals. (For remarks on this crystal, and this kind of compound form, see § 78.) *Imperfect crystallizations:* structure fibrous divergent, small reniform shapes; granular—particles of various sizes, sometimes impalpable.

H.=6—7. G.=6·5—7·1; 6·96, crystallized variety; 6·514, thin columnar variety. *Lustre* adamantine. *Streak* pale gray; in some varieties, pale brown. *Color* principally brown or black; sometimes red, gray, white, or yellow. Nearly transparent—opaque. *Fracture* subconchoidal, uneven. Brittle.

It contains, according to Klaproth, Thomson, and Berzelius,

		Cornwall.	Finbo.
Peroxyd of Tin	99.5	96·265	93·6
Oxyd of Columbium	—	—	2·4
Peroxyd of Iron	0·5	3·395	1·4
Sesquoxyd of Manganese	—		0·8
Silica	—	0·750	—
	100·0, K.	100·410, T.	98·2, B.

Before the blowpipe, on charcoal, it is reducible, but with difficulty; reduction takes place more rapidly if it is mixed with borax and carbonate of soda. It is infusible in acids. Fused with caustic potash it yields a mass which is mostly soluble in water; hydriodic acid throws down from the solution a yellow precipitate.

Obs. Tin ore is met with in veins traversing granite, gneiss, and mica slate.

Cornwall affords the finest and most remarkable simple crystals, associated with fluor, apatite, topaz, blende, wolfram, &c. The singular compound crystals come mostly from Bohemia and Saxony. The twin forms from Zinnwald and Schlackenwald often weigh several pounds. It is, however, found in the greatest abundance at Cornwall, though in smaller individuals, and under a great variety of crystalline forms, different veins affording distinct modifications. It also occurs in Galacia, Greenland, Sweden, the peninsula of Malacca, and the island of Banca, in Asia. Some specimens from the vicinity of Fahlun, where it occurs associated with topaz, albite, and quartz, contain, according to Berzelius, several per cent. of the oxyd of columbium. This is the Columbiferous oxyd of tin described by Phillips.

The *fibrous* or *wood tin* occurs in botryoidal and reniform shapes of a radiated structure, and composed of concentric coats. It occurs at Cornwall and Brazil. *Toad's eye tin* is the same, on a small scale. *Stream tin* is the alluvial debris of tin veins, separated from the deposits of gravel by washing. It occurs in the low grounds of Cornwall. The United States have afforded a few small crystals of tin at Chesterfield, Mass., associated with albite and turmaline. Pseudomorphs, imitative of feldspar, (a common mineral in the region,) have been found in Cornwall; and others composed of the white oxyd of tin, imitative of quartz.

The Cornwall mines have been worked from a very remote antiquity. The Tyrians, as early as the time of Moses, appear to have exported tin from this region. They now afford annually 4000 tons of tin, amounting in value to £300,000. The purest grain tin is obtained from the stream ore, which often yields 70 per cent. The block-tin is smelted from the ore dry from the veins.

Tin is employed for coating iron, and thus forms the material for the ordinary tin ware. Mixed with mercury, it composes the metallic covering of mirrors. With lead it forms pewter.

CERITE. CERITUS RHOMBOHEDRUS.

Rhombohedral Cerium-Ore. Siliciferous Oxyd of Cerium, Silicate of Cerium. Ochroite.

421. *Primary form:* tetraxonal. Massive; structure granular. H.=5·5. G.=4·912, Haidinger. *Lustre* adamantine. *Streak* grayish-white. *Color* between clove-brown and cherry-red, passing into gray. Slightly subtranslucent. *Fracture* splintery.

According to Hisinger and Vauquelin, it contains

Oxyd of Cerium	68·59	67
Silica	18·00	17
Oxyd of Iron	2·00	2
Lime	1·25	2
Water and Carbonic Acid	9·60=99·44, H.	12=100, V.

It is infusible, *per se*, before the blowpipe; with borax it forms a yellow globule, which becomes almost colorless on cooling.

Obs. It occurs at Bastnaes, near Riddarhyttan, in Westmanland, Sweden, forming a bed in gneiss, and associated with mica, hornblende, copper pyrites, cerine, &c. It bears considerable resemblance to the red granular variety of corundum, but is readily distinguished by its hardness.

THULITE. CERITUS RHOMBICUS.

422. *Primary form:* a rhombic prism of 92° 30′, and 87°

30′, according to Brooke, who also supposes it to be oblique. *Cleavage* parallel with M distinct. Occurs usually granular.

H.=5·5—6. G.=3·1055. *Lustre* vitreous. *Streak* grayish-white. *Color* rose-red. Translucent—subtranslucent. Particles of granular varieties easily separable.

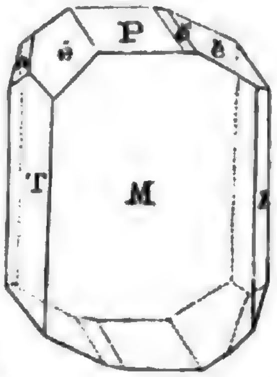
It contains, according to Thomson, (Min. i. 415,) Silica 46·10, Peroxyd of Cerium 25·95, Lime 12·50, Peroxyd of Iron 5·45, Potash 8·00, Moisture 1·55=99·55. The silica, as is stated by Thomson, was probably, in part, derived from the gangue, which he found it impossible to separate. Before the blowpipe, with carbonate of soda, it fuses into a colorless transparent bead, which, with the addition of saltpetre, assumes a sensibly violet color, indicating the presence of a trace of manganese.

Obs. It occurs at Souland, in Tellemark, Norway, in a rock consisting chiefly of quartz.

ALLANITE. Melanophæus triclinatus.

Anorthitic Melane-Ore, *Haid.* Prismatic Cerium Ore, *P.* Cerine.

423. *Primary form:* an oblique rhomboidal prism; M : T=116°. *Secondary form:* M : ĕ=129°, T : ĕ (adjacent planes) =115°, P : ē=156° 45, P : ĕ=151°, P : ĕ′ =164° 30, Haidinger, with the common goniometer. *Cleavage* in traces parallel to M and T. Occurs also in acicular aggregations. *Imperfect crystallizations:* structure impalpably granular.



H.=6. G.=4·001, when pure; if mixed with mica, as is often the case, it varies from 3·199—3·797. *Lustre* submetallic—resinous, occasionally massive varieties are vitreous; not of high degrees. *Streak* greenish-gray; sometimes inclining to brown. *Color* brownish or greenish-black; brown in thin splinters. Subtranslucent—opaque. *Fracture* subconchoidal. Brittle.

According to Stromeyer, (Poggendorf's Annalen, xxxii. 292,) it contains

	Allanite.	Cerite.
Silica	33·021	30·17
Alumina	15·226	11·31
Protoxyd of Cerium	21·600	28·19
Protoxyd of Iron	15·101	20·72
Protoxyd of Manganese	0·404	trace
Lime	11·080	9·12
Water	3·000=99·432.	— =99·51.

In the blowpipe flame it intumesces, and imperfectly fuses into a black scoria. It gelatinizes in nitric acid.

Obs. Cerine and orthite have been united with this species. It is preferable to retain the latter separate until further investigations explain more fully their relative characters.

Allanite occurs at Alluk, near the southern extremity of East Greenland, imbedded in granite. It usually appears in black vitreous-like masses, and is rarely crystallized. It was named in honor of Mr. Allan. Cerine is associated with cerite at Bastnaes, in Sweden.

THORITE. Melanophæus Thoriferus.

Berzelius, Kong. Vet. Acad. Handl. 1829, p. 1.

424. Massive and compact.

Not scratched by the knife. G.=4·63. *Lustre* of the surface of fresh fracture, vitreous; of exposed surface, resinous and dull. *Streak* dark brown. *Color* black, sometimes inclining to brown. *Fracture* conchoidal. Easily frangible.

It contains, according to Berzelius, Thoria 57·91, Silica 18·98, Lime 2·58, Peroxyd of Iron 3·40, Oxyd of Manganese 2·39, Magnesia 0·36, Water 9·50, with small portions of Oxyds of Lead and Tin, Peroxyd of Uranium, Potash, Soda, and Alumina.

Before the blowpipe it gives out water and becomes pale brownish-red, but does not fuse. Calcined in a tube it gives slight indications of fluoric acid. With carbonate of soda on platinum foil, it becomes green. It fuses easily with borax into a glass colored by iron.

Obs. It was found in sienite by M. Esmark, near Brevig, in Norway. It is stated to resemble Gadolinite in external characters. The new metal Thorium, was first discovered in this mineral by Berzelius.

ORTHITE. Melanophæus acicularis.

Orthite, *Berzelius*. Brews. Jour. III. 333.

425. Occurs in long acicular crystals, sometimes two feet long; also massive.

H.=5. G.=3·288. *Lustre* vitreous. *Streak* brownish-gray. *Color* black, inclining to ash-gray. Opaque. *Fracture* subconchoidal.

It contains, according to Berzelius, (Afhandlingar, v. 32,)

	Finbo.	Gottlich's vein.
Silica	36·25	32·184
Protoxyd of Cerium	17·39	20·510
Protoxyd of Iron	11·42	12·380
Alumina	14·00	14·810
Lime	4·89	7·960
Yttria	3·80	2·870
Protoxyd of Manganese	1·36	3·360
Water	8·70=97·81.	5·360=99·434.

Before the blowpipe it froths, becomes yellowish-brown, and melts with effervescence into a black vesicular globule. With borax it fuses easily into a clear glass, which in the reducing flame becomes greenish, and in the oxydizing flame blood-red; the last color mostly disappears on cooling.

Obs. Orthite occurs in quartz, in acicular crystals, sometimes exceeding a foot in length, at Finbo, near Fahlun, in Sweden. At Skeppholm it is disseminated in black vitreous masses through granite. Orthite also occurs at Lindenaes, in Norway, and was brought from Greenland by Giesëcké. The name, *orthite*, is derived from ορθος, *straight*, in allusion to the straight acicular form of the crystals.

PYRORTHITE. Melanophæus flammans.

426. In long thin imbedded crystals, without any distinct form; usually aggregated.

H. below 3. G.=2·15—2·25. *Lustre* resinous. *Streak* and *color* brownish-black; if weathered, yellowish-brown. Opaque. *Fracture* conchoidal, splintery, earthy.

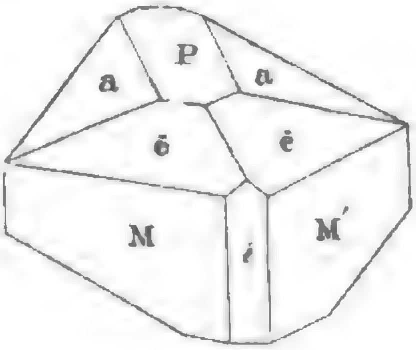
It contains, according to Berzelius, (Afhandlingar, v. 49,) Silica 10·43, Protoxyd of of Cerium 13·92, Carbon 31·41, Water 26·50, Protoxyd of Iron, 6·08, Yttria 4·87, Alumina 3·59, Lime 1·81, Protoxyd of Manganese 1·39=98·39.

It takes fire when gently heated, and burns without either flame or smoke. Subsequently it whitens, and fuses into a black enamel. With borax it affords a transparent glass. In heated acids it dissolves with the exception of a black powder.

Obs. It occurs in a vein of granite, traversing gneiss, at Karafvet, near Fahlun, in Sweden, associated with Gadolinite. It resembles the orthite of the same region, except in its low degree of lustre.

GADOLINITE. Melanophæus obliquus

Prismatic Melane-Ore, *Haid.* Gadolinit, *W.*



427. *Primary form:* an oblique rhombic prism; M : M (according to Phillips) =115°, as determined with the common goniometer; according to Haüy it equals 109° 28′. *Secondary form:* M : ē=153°, ē : ē=120°. *Cleavage* very indistinct. Massive; structure impalpably granular.

H.=6·5—7. G.=4·14—4·3; 4·1795, Thomson; 4·238, Haidinger. *Lustre* vitreous, inclining to resinous. *Streak* greenish-gray. *Color* black or greenish-black. Subtranslucent—opaque. *Fracture* conchoidal.

It contains, according to Thomson and Steel, and Richardson, (Thomson's Min. i. 410,)

Silica	24·330	24·65
Yttria	45·330	45·20
Protoxyd of Cerium	4·333	4·60
Glucina	11·600	11·05
Protoxyd of Iron	13·590	14·55
Manganese	trace	——
Moisture	0·986=100·169, T. and S.	0·50=100·55, R.

It decrepitates in the blowpipe flame, and when in thin splinters is fused: heated with caution on charcoal, it exhibits a vivid glow, and the color becomes paler. It loses its color in heated nitric acid, and is converted into a jelly.

Obs. Gadolinite occurs principally in the quarries of Karafvet and Finbo, near Fahlun, in Sweden; also at Ytterby, near Stockholm. At each locality it occurs indistinctly crystallized, and in rounded masses, which are often encircled with a yellow crust and imbedded in a coarse grained granite. At Karafvet, crystals have been obtained four inches long. It has also been met with at Disko, in Greenland, and imbedded in granite, in Ceylon.

This mineral was first noticed by Capt. Arhenius, at Ytterby, and analyzed by M. Gadolin, who discovered in it a new earth, which afterwards was named *yttria*, from its locality, Ytterby.

TITANIFEROUS CERITE. Melanophæus Laugieri.

Laugier, Ann. de Chim. et de Phys. XXVII. 313.

428. H.=6·5—7. *Lustre* vitreous. *Color* blackish brown. *Fracture* conchoidal. It contains Oxyd of Cerium 36, Oxyd of Iron 19, Lime 8, Alumina 6, Water 11, Oxyd of Manganese 1·8, Silica 19, Oxyd of Titanium 8; the excess above 100 of the sum of these quantities, has arisen from a change of the protoxyd of cerium to a peroxyd, during the analysis. It swells up when heated, and is attacked both by acids and alkalies.

Obs. It has been found on the Coromandel coast.

ÆSCHYNITE. Melanophæus Mengianus.

Æschonite, *Brooke*. Ann. of Phil. x. 188. *Leonhard*.

429. *Primary form:* an oblique rhombic prism of about 127°, according to Brooke.

H. = 5—6. G. = 5·14—5·55. *Lustre* resinous——submetallic. *Streak* dark gray, almost black. *Color* nearly black, inclining to brownish yellow when translucent. Translucent—opaque. *Fracture* small subconchoidal.

It contains, according to Hartwall, (Poggend. Ann. xvii. 483,) Titanic Acid 56, Zirconia 20, Peroxyd of Cerium 15, Lime 3·8, Peroxyd of Iron 2·6, Peroxyd of Tin 0·5. Before the blowpipe, on charcoal, it swells and becomes yellow; with borax it readily forms a dark-yellow glass; with salt of phosphorus it yields a transparent colorless bead.

Obs. This mineral was brought by Menge from Minsk, in the Ural, where it occurs imbedded in feldspar, and associated with mica and zircon. The name of this mineral is derived from *αισχυνη, modesty*.

ŒRSTEDITE. Melanophæus quadratus.

430. *Primary form:* a right square prism. *Secondary form:* the primary with the angles and edges replaced; a : a=123° 16½′.

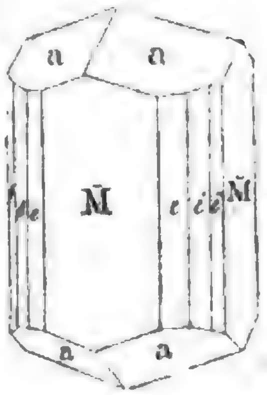
H.=5·5. G.=3·629. *Lustre* splendent. *Color* brown.

It contains Titanate of Zirconium 68·965, Silica 19·708, Lime 2·612, Magnesia 2·047, Protoxyd of Iron, 1·136, Water 5·332=99·80.

Obs. It occurs in brilliant highly modified crystals at Arendal, Norway, and is commonly found upon crystals of pyroxene. This species was discovered by Forchhammer, and named in honor of Œrsted.

POLYMIGNITE. Melanophæus rectangulus.

Berzelius, Kong. Vet. Acad. Handl. 1824, p. 388; Brewster's Jour. III. 329.



431. *Primary form:* a right rectangular prism. *Secondary form:* a : a=136° 28′, M : *e* =154° 8′, (calculated.) *Cleavage* in traces parallel to M and T. The crystals are generally slender and thin, and striated longitudinally.

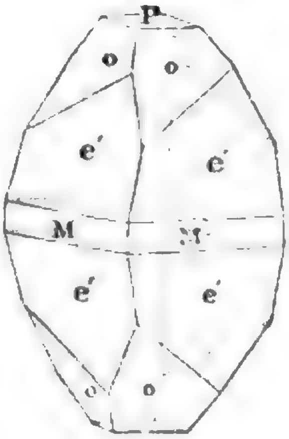
H.—6·5. G.=4·77—4·85. *Lustre* submetallic, but brilliant. *Streak* dark-brown. *Color* black. Opaque. *Fracture* perfect conchoidal, presenting, like the surface, a brilliancy almost metallic.

Berzelius obtained the following for its composition, in an analysis of 10·16 grains: Titanic Acid 46·3, Zirconia 14·4, Peroxyd of Iron 12·2, Lime 4·2, Sesquoxyd of Manganese 2·7, Peroxyd of Cerium 5·0, Yttria 11·5. *Per se*, the blowpipe produces no effect; with borax it fuses readily into a glass, colored by iron. The addition of more borax renders it opaque and orange-colored.

Obs. It occurs at Fredrickswarn and Stavearn, in Norway, imbedded in feldspar and zircon sienite. Its crystals sometimes exceed an inch in length. It was named by Berzelius, in allusion to the number of substances that enter into its composition, from *πολὺς, many*, and *μιγνύω, to mix*.

FERGUSONITE. Columbus hemiquadratus.

Haidinger, Edin. Trans. X. 274.



432. *Primary form:* a right square prism. *Secondary form:* o : o=100° 28′.

H.=5·5—6. G.=5·838, Allan; 5·800, Turner. *Lustre* externally dull, on the fracture brilliantly vitreous. *Streak* very pale brown. *Color* brownish black; in thin scales it is pale liver-brown, or yellowish-brown. Subtranslucent—opaque. *Fracture* perfect conchoidal.

It contains, according to M. Victor Hartwall, (Kong. Vet. Acad. Handl. 1828, p. 167,)

Columbic Acid	47·75
Yttria	41·91
Protoxyd of Cerium	4·68
Zirconia	3·02
Oxyd of Tin	1·00
Oxyd of Uranium	0·95
Peroxyd of Iron	0·34=99·65.

It is infusible before the blowpipe, but loses its color; with borax it fuses with difficulty, and forms a glass which is yellow while hot, with some interspersed white spots of undissolved matter. With carbonate of soda it is decomposed and fuses, leaving a reddish slag.

Obs. It was discovered by Giesècké, at Kikertaursak, near Cape Farewell, in Greenland, disseminated in quartz. It was named in compliment to Robert Ferguson, Esq., of Raith.

YTTRO-COLUMBITE. Columbus Berzelii.

Yttro-Tantalite. Tantale Oxidé Yttrifère, *H.* Discolumbate of Yttria, Triscolumbate and Tetracolumbate of Yttria, *Thomson.*

433. There are three varieties of this species, which require a separate notice; the *black*, the *yellow*, and the *brown* or *dark* yttro-columbite.

The *black* exhibits indistinct traces of crystallization. H.=5·5. G.=5·395. *Lustre* submetallic. *Streak* gray. *Color* black. Opaque.

The *yellow* never exhibits a crystalline form, but occurs in laminæ in the fissures of feldspar. H.=5. G.=5·882, Ekeberg. *Lustre* resinous on the surface, vitreous in the fracture. *Streak* white. *Color* yellowish-brown—greenish. Opaque.

The *brown* occurs with the yellow, in thin plates, or rarely grains, presenting no trace of crystallization. H.=4·5—5. *Lustre* vitreous, inclining to resinous. *Streak* white. *Color* black, with a very light shade of brown, slightly yellow when in thin plates by transmitted light.

These varieties contain, according to Berzelius, (Afhandlingar, iv. 268, 272,)

	Black.		Yellow.		Brown.
Columbic Acid	57·00		60·124		51·815
Yttria	20·25		29·780		38·515
Tungstic Acid	8·25	With Tin	1·044	With Tin	2·592
Lime	6·25		0·500		3·260
Peroxyd of Iron	3·50		1·155		0·555
Oxyd of Uranium	0·50=95·75.		6·622=99·225.		1·111=97·848.

Each of these varieties is infusible alone before the blowpipe, but they decrepitate and assume a light color. The black variety froths, and fuses with carbonate of soda. They dissolve in borax, but are not acted upon by acids.

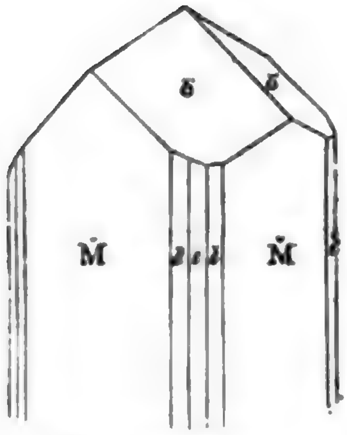
Obs. These varieties of yttro-columbite occur in Sweden at Ytterby, in red feldspar, and at Broddbo and Finbo, near Fahlun, imbedded in quartz and albite, and associated with garnet, mica, and the pyrophysalite variety of topaz. We are indebted to Berzelius for the discovery and description of these several varieties.

COLUMBITE. Columbus rectangulus.

Prismatic Tantalum-Ore, *J.* and *M.* Tantalit *of the Germans.* Tantale Oxidé, *H.* Columbite, *Hatchett.*

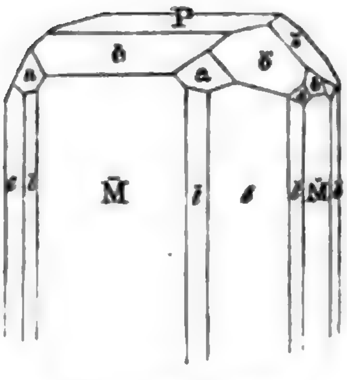
434. *Primary form:* a right rectangular prism. *Secondary forms:*

1.



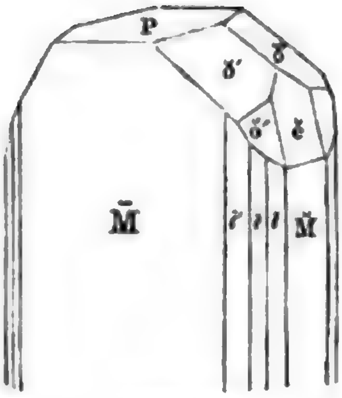
Middletown, Conn.

2.



Middletown, Conn.

3.



Bohemia.

M̄ : *e*=140° 20′, M̆ : *e*=129° 40′, M̄ : *ē*=157° 29′, M̆ : *ĕ*=158° 6′, M : *ē*=112° 31′, P : ē=160° 34′, P : ĕ=119° 40′, M̄ : ē=109° 26′, M : ĕ=150° 20′, P : a=126° 2′, a : a (over ŏ′) =102° 58,′ a : *c*=143° 58′, P : ŏ′=136° 36′, ŏ′ : ŏ′=150° 17′, a : ŏ′=156° 20½′, ŏ′ : *ĕ*=133° 24′, P : ŏ″=119° 13′, ŏ″ : ŏ″ (over ĕ) =160° 29′, ĕ : ŏ″=170° 14½′. The above angles, the most of which have been calculated, agree very closely with observation. The following are the values of the above angles, obtained by Brooke with the common goniometer, from a specimen supposed to have been found at Bodenmais, in Bavaria: M̆ : *ĕ*=158° 6′, M̆ : *ĉ*=114° 30′, P : ĕ=120°, P : *ŏ′*=136° 30′. Dr. Torrey found the angle M̆ : *ĕ*, of a crystal (fig. 1) from Haddam (Ann. New York Lyc. I. 89) to equal 157°, and M̆ : *e*= 129° 50′. *Cleavage* parallel with M̄ and M̆ rather distinct, the former the most so; parallel with P indistinct. Occurs also massive; structure granular.

H.=5—6. G.=5·9—7·9. *Lustre* submetallic. *Streak* dark-brown, slightly reddish; brownish-black; a little shining. *Color* iron-black, brownish-black, grayish-black. Opaque. *Fracture* subconchoidal, uneven. Brittle.

From the unusual variation in the specific gravity of the different specimens of Columbium ore, it is probable that the subdivision of this species, which has been proposed, will prove necessary. Agreeably to this subdivision, the American and Bodenmais specimens, from their identity in crystallization, compose the species Columbite. Their *specific gravity* varies from 5·9—6·04. In two successive trials, with a specimen from Middletown, Conn., I obtained 5·95 and 5·948. The *hardness* of the Middletown specimens is often as low as 5, and does not exceed 5·5: that of the Bodenmais specimens is stated at 6.

Specimens from Haddam and Middletown frequently present the blue or reddish tints of the steel tarnish.

The following is the composition of this division of this species, according to Borkowsky, Vogel, and Thomson:

	Bodenmais.	Bodenmais.	Middletown, Conn.	Bodenmais.
Columbic Acid	74·0	75	73·90	79·65
Protox. Iron	20·0	17	15·65	14·00
Protox. Manganese	4.6	5	8·00	7·55
Oxyd of Tin	0·4	1	—	0·50
Water	—	—	0·35	0·05
	99·0, B.	98, V.	97·90, T.	101·75, T.

Dr. Wollaston obtained from four grains of the original specimen in the British Museum, sent out from Connecticut by Gov. Winthrop to Sir Hans Sloane, Columbic Acid 80, Protoxyd of Iron 15, Protoxyd of Manganese 5=100.

The second species which has been separated from Columbite, retains the German name of this species, *Tantalite*, or *Kimito Tantalite*, from its locality. Its specific gravity is stated by Ekeberg at 7·236, by Klaproth at 7·3. It contains, according to Berzelius, Columbic Acid 83·2, Protoxyd of Iron 7·2, Protoxyd of Manganese 7·4, Oxyd of Tin 0·6=98·4.

The third is a nearly pure Columbate of iron. Its specific gravity is 7·655, according to Berzelius; 7·963, according to Ekeberg. Its lustre is more perfectly metallic, and its streak a purer reddish brown than the preceding. Berzelius obtained for its composition, Columbic Acid 85·85, Protoxyd of Iron 12·97, Protoxyd of Manganese 1·6, Oxyd of Tin 0·80, Lime 0·56, Silica 0·72=102·51. Thomson proposes the name *ferrotantalite* for this variety.

The Broddbo Columbite contains a large proportion of tin, and has a specific gravity of 6·5. The following are the results of three analyses by Berzelius:

Columbic Acid	66·66	68·22	66·345
Oxyd of Tin	8·02	8·26	8·400
Tungstic Acid	5·78	6·19	6·120
Oxyd of Iron	10·64	9·58	11·070
Oxyd of Manganese	10·20	7·15	6·600
Lime	— =101·30.	1·19=100·59.	1·500=100·035.

Before the blowpipe alone, on charcoal, Columbite is infusible. With borax, in powder, fusion is slowly but perfectly effected.

Obs. The Columbite of Bodenmais, Bavaria, and also of Rabenstein, near Zweisel, in Bohemia, occurs in granite; the Kimito tantalite, Finland, in red feldspar; and the specimens which occur near Fahlun, in Sweden, in albite and quartz.

The occurrence of Columbite in this country was first made known by Mr. Hatchett's examination of a specimen, sent by Gov. Winthrop to Sir Hans Sloane, then President of the Royal Society, which was labelled as found at Neatneague. Dr. S. L. Mitchill stated, (Med. Repos. vol. VIII.) that it was taken from a spring at New London, Conn. No locality has since been detected at that place. But the rediscovery of it at Haddam, first published by Dr. Torrey, (Silliman's Amer. Jour. IV. 52,) has led to the belief, that the latter was its original locality. It has since been discovered more abundantly near Middletown, Conn.

At Haddam it occurs in a granite vein, associated with chrysoberyl, beryl, Pinite, and automolite. Much finer and larger crystals have been afforded by the Middletown locality, where it occurs in a feldspar quarry. The above figure, 2, represents one of these crystals three quarters of an inch long; its faces are sufficiently brilliant to permit the use of the reflecting goniometer. A crystal from this locality has lately been described (Silliman's Amer. Journ. XXX. 387) by Professor Johnston, of the Wesleyan University of Middletown, which weighed, before it was broken, 14 pounds. The part figured weighed 6 lbs. 12 oz. avoirdupois, and exceeded 7 inches in length and breadth. It exhibits the faces M̄, M̆, e, ē′, ė, ĕ, and another imperfect plane, which appears to be ō′. Chesterfield, Mass., has afforded some fine crystals, associated with blue and green turmalines, and beryl, in granite; also quite large and perfect crystalline individuals have been found at Acworth, N. H., but the locality is now apparently exhausted.

PITCHBLENDE. URANIUS AMORPHUS.

Uncleavable Uranium Ore, *M.* Uranium-Ore, *M.* Uran-Ochre, *P.* Protoxyd of Uranium, Pechera, *W.* Pechuran, *Haus.* Urane Oxydulé, *H.*

435. Massive and botryoidal; also in grains.

H.=5·5. G.=6·468. *Lustre* submetallic, or dull. *Streak* black, a little shining. *Color* grayish, brownish, or velvet-black. Opaque. *Fracture* conchoidal, uneven.

It contains, according to Klaproth, (Beitrage ii. 221,) Protoxyd of Uranium 86·5, Protoxyd of Iron 2·5, Silica 5·0, Sulphuret of Lead, 6·0.

Alone, before the blowpipe, it is infusible; but with borax it melts into a gray scoria. In the state of powder, it dissolves slowly in nitric acid, attended with the formation of the red fumes of nitrous acid. It is not attractable by the magnet.

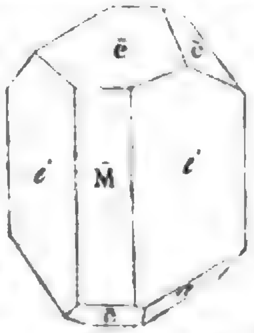
Obs. Pitchblende accompanies various ores of silver and lead at Johanngeorgenstadt, Marienberg, and Schneeberg, in Saxony; at Joachimsthal and Przibram, in Bohemia; also at Rezbanya, in Hungary; it is associated with uranite in some of the Cornish mines.

It is employed in porcelain painting, affording an orange-color in the enameling fire, and a black one in that in which the porcelain is baked.

WOLFRAM. Wolframius rectangulus.

Prismatic Scheelium Ore, *M.* Tungstate of Iron. Tungstate of Iron and Manganese, Scheelate of Iron and Manganese. Scheelin Ferruginé, *H.*

436. *Primary form:* a rectangular prism. *Secondary form:* e′ : e′=101° 5′, ē : ē (over the apex) =125° 20′. *Cleavage* perfect parallel with M. *Compound crystals:* composition parallel to M; other twins occur in which composition takes place parallel to ĕ, or is of the *second kind.* *Imperfect crystallizations:* structure irregular lamellar; also coarse divergent columnar; granular—particles strongly coherent. *Pseudomorphs* imitative of tungstate of lime.



H.=5—5·5. G.=7·1—7·4. *Lustre* submetallic. *Streak* dark reddish-brown. *Color* dark grayish or brownish-black. Opaque.

According to Berzelius and Vauquelin, it contains

Tungstic Acid	74·666	73·511
Protoxyd of Iron	17·594	20·745
Protoxyd of Manganese	5·640	5·744
Silica	2·100=100, B.	——=100, V.

It decrepitates before the blowpipe, and melts at a high temperature into a globule, whose surface is covered with crystals, having a metallic lustre. With borax it forms a green bead. With salt of phosphorus it fuses into a clear globule of a deep red color.

Obs. Wolfram is often associated with tin ores; also with galena, in veins traversing gray-wacke; also in quartz, with native bismuth, tungstate of lime, pyrites, galena, blende, &c.

It occurs at Cornwall, much to the detriment of the tin ores; in fine crystals at Schlackenwald, Zinnwald, Ehrenfriedersdorf; also at Limoges, in France, and in the island of Rona, one of the Hebrides.

In the United States it occurs at Lane's mine, Monroe, Conn., in quartz, associated with native bismuth, and the other minerals above mentioned. Pseudomorphs, of the form of tungstate of lime, are often observed at this locality. It has also been met with in small quantities in Trumbull, Conn., in the topaz vein.

HAUSMANNITE. Manganus acrotomus.

Pyramidal Manganese Ore, *M.* Foliated Black Manganese Ore, *J.* Black Manganese. Red Oxyd of Manganese. Blättriger Schwartz-Braunstein, *Haus.* Manganèse Oxydé Hydraté, *H.*

437. *Primary form:* a square octahedron. *Secondary form:* fig. 57, Pl. I.; a : a=105° 25′, a : a (in different pyramids) =117°

54′, a′ : a′=139° 56′. *Cleavage* rather perfect parallel to the base of the octahedron. *Compound crystals:* somewhat similar to fig. 129: the same kind of composition sometimes takes place between four individuals. *Imperfect crystallizations:* structure granular, particles strongly coherent.

H.=5—5·5. G.=4·722. *Lustre* submetallic. *Streak* chesnut-brown. *Color* brownish-black. Opaque. *Fracture* uneven.

It contains, according to Turner, (Edinb. Trans. xi.) Red Oxyd of Manganese 98·098, Oxygen 0·215, Water 0·435, Baryta 0·111, Silica 0·337=99·196.

In the oxydating flame of the blowpipe it affords an amethystine globule. It dissolves in heated muriatic acid, yielding an odor of chlorine.

Obs. It occurs in porphyry, with other manganese ores, near Ilmenau, in Thuringia, and at Framont, in Alsatia, in fine crystals. It has been observed at Lebanon, Pennsylvania.

BRAUNITE. MANGANUS PERITOMUS.

Brachtypous Manganese-Ore, *M.* Anhydrous Sesqui-oxide of Manganese, *Thom.*

438. *Primary form:* a square octahedron of nearly the dimensions of the regular octahedron; A : A=109° 53′. *Secondary form:* similar to the last species. Occurs also massive.

H.=6—6·5. G.=4·818. *Lustre* submetallic. *Streak* and *color* dark brownish-black. *Fracture* uneven. Brittle.

It contains, according to Turner, (Edinb. Trans. xi.) Protoxyd of Manganese 86·94, Oxygen 9·851, Water 0·949, Baryta 2·260, and a trace of Silica. It is, therefore, a sesquoxyd of manganese. It dissolves in muriatic acid, leaving a silicious residue.

Obs. It occurs both crystallized and massive, in veins traversing porphyry at Oehrenstock, near Ilmenau, at Elgersburg, and elsewhere, in Thuringia; also with red epidote, at St. Marcel, in Piedmont. This species was named in compliment to Mr. Braun, of Gotha.

PSILOMELANITE. MANGANUS INFORMIS.

Uncleavable Manganese-Ore, *M.* Compact and Fibrous Manganese Ore. Black Hematite. Compact Gray Oxyd of Manganese. Black Iron Ore. Psilomelanite. Schwarzeisenstein, *W.* Fasriger and Dichter Schwarzbraunstein, *Haus.* Dichtes Schwarz-Manganerz, *L.* Manganese Oxidé Hydraté Concretionné.

439. Crystalline form has not been observed. Occurs massive and botryoidal.

H.=5—6. G.=4—4·328. *Lustre* submetallic. *Streak* reddish, brownish-black, shining. *Color* black, passing into dark steel-gray. Opaque. *Fracture* not observable.

It contains, according to Turner, (Edinb. Trans. xi.) Red Oxyd of 69·795, Oxygen 7·364, Baryta 16·365, Silica 0·260, Water 6·216=100.

It gives a violet color to borax, and is completely soluble in muriatic acid, excepting a small quantity of silica.

Obs. This is one of the most generally diffused ores of manganese. It frequently occurs in alternating layers of different thicknesses, with pyrolusite. It occurs in botryoidal and stalactitic shapes, in Devonshire and Cornwall; at Ihlefield, in the Hartz; also in Hessia, Saxony, &c.

This species occurs also in mammillary and botryoidal masses, at Chittenden, Vt.

The name psilomelanite, is derived from ψιλος, *smooth* or *naked*, and μελας, *black*, and was given it on account of its smooth botryoidal forms and black color. The manganèse oxidé noir barytifère, from Romanèche, has a somewhat higher specific gravity, but in other respects resembles this species.

CUPREOUS MANGANESE. MANGANUS CUPRIFERUS.

Kufermangan *of the Germans.*

440. Massive, in small reniform and botryoidal groups.

H.=1·5. G.=3·15—3·25. *Lustre* resinous. *Streak* and *color* bluish-black. Opaque.

It contains, according to Lampadius, Black Oxyd of Manganese 82, Brown Oxyd of Copper 13·50, Silica 2, and, according to Berzelius, a considerable quantity of water. Before the blowpipe it becomes brown, but does not fuse; to borax and salt of phosphorus it communicates amethystine and green colors, and the other characteristic indications of copper and manganese.

Obs. This rare mineral occurs in the tin mines of Schlaggenwald, in Bohemia; it was distinguished by Breithaupt and Lampadius.

MANGANITE. MANGANUS RHOMBICUS.

Prismatoidal Manganese-Ore, *M.* Gray Manganese-Ore. Gray Oxide of Manganese. Hydrous Sesquoxyd of Manganese, *Thom.* Grauer Braunstein, *W.* Manganese Oxydé, *H.*

441. *Primary form:* a right rhombic prism; M : M=99° 40′. *Secondary form* and *twin crystal*, fig. 15, Pl. III.; crystals longitudinally striated. In this crystal composition is of *the third kind*, and has been effected parallel to the plane *a* on the acute solid angle. Other twins occur, composed of two individuals united by their acute lateral edges. *Imperfect crystallizations:* structure columnar; also granular.

H.=4—4·5. G.=4·3—4·4. *Lustre* submetallic. *Streak* reddish-brown, sometimes nearly black. *Color* dark steel-black—iron-black. Opaque; minute splinters cleaved off sometimes exhibit a brown color by transmitted light, when exposed to the direct light of the sun. *Fracture* uneven.

It contains, according to Turner and Gmelin,

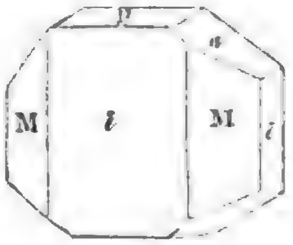
Red Oxyd of Manganese	86·85	87·1
Oxygen	3·05	3·4
Water	10·10=100, T.	9·5=100, G.

Before the blowpipe alone it is infusible; with borax it yields a violet-blue globule. It is insoluble in nitric acid; in muriatic acid it gives off chlorine and dissolves without a residue.

Obs. It occurs in veins traversing porphyry, associated with calcareous spar and heavy spar, at Ihlefield, in the Hartz; also in Bohemia, Saxony, Aberdeenshire. The gray oxyd from Undenaes, in West Gothard, analyzed by Arfwedson, is a similar compound. It is important in the manufacture of glass, and in bleaching operations.

PYROLUSITE. MANGANUS PRISMATICUS.

Prismatic Manganese-Ore, *M.* Gray Ore of Manganese. Wad. Anhydrous Binoxide of Manganese, *Turner.*



442. *Primary form:* a right rhombic prism; M : M=93° 40′. *Secondary form:* M : $\bar{e}$=136° 50′, M : $\breve{e}$=133° 10′. *Cleavage* parallel to M and $\bar{e}$, $\breve{e}$. *Imperfect crystallizations:* structure columnar—often divergent; also granular; frequently in reniform coats; often soils when massive.

H.=2—2·5. G.=4·819, Turner; 4·97 when pure. *Lustre* metallic. *Streak* black. *Color* iron-black, sometimes bluish. Opaque. Rather sectile.

It contains, according to Turner and Thomson,

Red Oxyd of Manganese	84·05	85·62		} 99·242
Oxygen	11·78	11·60		
Water	1·12	1·56		—
Baryta	0·53	0·55	Perox. Iron	0·130
Silica	0·51	0·66		0·840
	97·99, Turn.	99·99, Turn.		100·212, Th.

With borax it affords an amethystine globule; heated in a matrass it yields no water.

OBS. This ore is extensively worked at Elgersburg, Ilmenau, and other places in Thuringia; also at Ehrensdorf, near Maehrish, Triebau, in Moravia, which place annually affords many hundred tons of this ore. At each of these places it is associated with psilomelanite. The finest crystals occur at Schimmel and Oslerfreude, near Johanngeorgenstadt, and at Hirschberg, in Westphalia.

In the United States it occurs, associated with psilomelanite, abundantly in different parts of Vermont, at Bennington, Monkton, Chittenden, &c., both crystallized similar to the above figure, and massive. It is also found at Conway, Mass., in a vein of quartz; at Winchester, N. H.; at Salisbury and Kent, Conn., forming velvet-like coatings on brown iron ore.

Pyrolusite parts with its oxygen at a red heat, and is, therefore, extensively employed for discharging the brown and green tints of glass. It hence received its name from πυρ, *fire*, and λυω, *to wash;* and for the same reason is whimsically entitled by the French, *le savon de verriers.* It is easily distinguished from psilomelanite by its inferior hardness.

Berthier has described a species of manganese ore differing from pyrolusite in composition, by containing one atom of water in two atoms of the mineral.

It occurs in rounded pieces in sand and clay at Groroi, Cautern, and Vecdessos, in France. *Color* brownish-black. *Lustre* dull, submetallic. *Streak* light-chocolate. It dissolves slowly in concentrated sulphuric acid, and colors that acid a fine violet-red. By ignition it loses 24 per cent. of its weight in water and oxygen, without changing its form, but acquires a reddish color.

EARTHY COBALT. MANGANUS COBALTIFERUS.

Earthy Cobalt, *P.* Erdkobold. *W.* Schwarzer Erdkobalt, *Haid.* Cobalt Oxidé Noir, *H.*

443. Massive botryoidal, earthy and granular.

Soft. G.=2·24. *Lustre* somewhat resinous. *Streak* shining. *Color* bluish and brownish-black. Opaque. Sectile.

According to Döbereiner, it contains Oxyds of Cobalt and Manganese 76·9, and Water 23·1. Before the blowpipe it emits the odor of arsenic, but does not fuse. It colors glass of borax blue.

Obs. It occurs in sandstone, associated with lead and copper, at Alderly Edge, in Cheshire; with green malachite at Nertschinsk, in Siberia; with several species of cobalt pyrites at Reichelsdorf, in Hessia, and Saalfield, in Thuringia.

It is employed in the manufacture of smalt.

Its brilliantly shining *streak* is an important peculiarity, and may assist in distinguishing it.

WAD. Manganus terrenus.

Earthy Manganese.

444. In reniform, botryoidal, and arborescent shapes, and in froth-like coatings on other minerals; also massive.

H.=0·5. G.=3·7. *Lustre* dull, earthy. *Streak* and *color* brown or black. Opaque. *Fracture* earthy. Very sectile. Soils.

It contains, according to Klaproth, Oxyd of Manganese 68, Oxyd of Iron 6·5, Water 17·5, Carbon 1·0, Baryta and Silica 9·0. Heated in the matrass it gives off much water. Berzelius considers it a hydrate of manganese. Mixed with linseed oil it undergoes spontaneous combustion.

Obs. On account of the porous nature of this mineral, it appears to be very light when held in the hand; but on immersing it in water it imbibes water rapidly, and gives the above specific gravity. This species has been found principally in the manganese pits, near Exeter, in Devonshire, Cornwall, the Hartz, and Piedmont. It is supposed to be the coloring ingredient of the common dendritic delineations upon limestone, steatite, and other substances.

VARVACITE.

445. Occurs in thin plates and fibres, often radiating; crystalline form not apparent.

H.=2·5—3. G.=4·283—4·623. *Lustre* submetallic. *Streak* black. *Color* steel-gray, iron-black. Opaque.

According to Mr. R. Phillips, it contains Protoxyd of Manganese 81·12, Oxygen 13·48, Water 5·40.

Obs. It occurs in the country of Warwick, and was therefore named as above. It has also been observed in the Hartz.

NEWKIRKITE.

446. Occurs in small needles, under the microscope apparently rectangular prisms.

H.=3—3·5. G.=3·824. *Lustre* metallic splendent. *Color* a brilliant black. Opaque. Rather sectile.

It contains, according to W. Muir, Deutoxyd of Manganese 56·30, Peroxyd of Iron 40·35, Water 6·70=103·35.

Obs. It occurs forming a coating on red Hæmatite, at Newkirchen, in Alsace, and was named by Thomson from its locality.

CHROMIC IRON. Siderus Chromicus.

Octahedral Chrome Ore, *M.* Chromate of Iron. Chromiron Ore. Chromeisenstein. Eisen Chrom Fer Chromaté.

447. *Primary form:* the regular octahedron. *Secondary*

form: fig. 9, Pl. I., from Hoboken, N. J., and Bare Hills, near Baltimore. Occurs usually massive—structure granular—particles strongly coherent.

H.=5·5. G.=4·321 of crystals, Thomson; 4·498, a variety from Stiria. *Lustre* submetallic. *Streak* brown. *Color* between iron-black and brownish-black. Opaque. *Fracture* uneven. Brittle.

It contains, according to Klaproth, Thomson, and Abich,

		Baltimore.		
Green Oxyd of Chromium	55·5	52·95		60·04
Protoxyd of Iron	33·0	29·24		20·13
Alumina	6·0	12·22		11·85
Water	—	0·70		—
Silica	2·0	trace		—
White substance undetermined	—	3·09	Magnesia	7·45
	96·5, Klap.	98·20, Thom.		99·47, Abich.

It is infusible alone before the blowpipe. With borax it fuses with difficulty, but completely, into a beautiful green globule. In small fragments it is attracted by the magnet.

Obs. Chromate of Iron occurs only in serpentine rocks, forming veins, or in imbedded masses. It assists in giving the variegated color of verd-antique marble.

It occurs in the Gulsen mountains, near Kraubat, in Styria; also in the islands of Unst and Fetlar, in Shetland; in the Department du Var in France, Silesia, Bohemia, &c.

At Baltimore, Md., in the Bare Hills, it occurs in large quantities in veins or masses in serpentine; also in Montgomery county, six miles north of the Potomac. It occurs both massive and in crystals, at Hoboken, N. J., imbedded in serpentine and dolomite; also at Milford and West Haven, Conn.; also in large masses in the southwestern part of the town of New Fane, Vt.

This ore affords the oxyd of chrome, which, both alone and in combination with the oxyds of other metals, is extensively used in oil-painting, dyeing, and in coloring porcelain.

CROCIDOLITE. Siderus fibrosus.

Krokidolite, *Hausmann.* Blue Iron Stone, *Klaproth.*

448. Fibrous—fibres long but very minute and easily separable; also massive.

H.=4. G.=3·2—3·265. *Streak* and *Color* lavender-blue or leek-green. Opaque. Fibres somewhat elastic.

According to Stromeyer, (Poggendorf's Annalen, xxiii. 156,) the fibrous variety contains

Silica	50·81	51·64
Protoxyd of Iron	33·88	34·38
Protoxyd of Manganese	0·17	0·02
Magnesia	2·32	2·64
Lime	0·02	0·05
Soda	7·03	7·11
Water	5·58=99·81.	4·01=99·85.

When heated to redness, it melts easily into a black shining, opaque, and somewhat frothy glass, which is attractable by the magnet. The single fibres readily fuse in the flame of a spirit lamp. With borax it forms a green transparent bead, which, by adding salt petre, is changed to brown.

Obs. It occurs at Orange river, near the Cape of Good Hope. Stavern, in Norway, is stated as another locality; but the mineral it affords does not precisely resemble the African variety. The name of this species is derived from κροκις, *woof*, in allusion to its wool-like fibrous structure.

HISINGERITE. Siderus Hisingeri.

Hisingerit, *Berz.* Thraulite, *Kobell.* Hydrous Sesqisilicate of Iron.

449. Imperfectly crystallized. *Cleavage* distinct in one direction. Soft. G.=3·045. *Streak* greenish-gray or brownish-yellow. *Color* black. Opaque. Cross fracture earthy. Sectile.

It contains, according to Berzelius, Hisinger, and Kobell,

Oxyd of Iron	51·50	49·869	50·86
Silica	27·50	31·775	31·28
Alumina	5·50	——	——
Oxyd of Manganese	0·77	——	——
Volatile matter	11·75	Water 20·700	Water 19·12
Magnesia	trace=97·02, B.	——=102·344, H.	——=101·26, K.

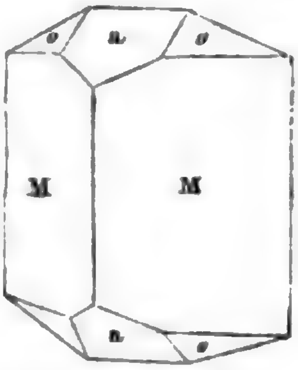
Heated in a glass tube it gives out water. Before the blowpipe it becomes magnetic, and at a high temperature melts into a dull opaque black globule; with borax it forms a yellowish-green glass.

Obs. It occurs in the cavities of calcareous spar, in the parish of Svärta, in Sudermanland, Sweden; also at Bodenmais, in Germany.

YENITE. Siderus rhombicus.

Di-Prismatic Iron Ore, *M.* Yenite, Ilvait, *Haus.* Fer Calcareo-Silicieux, *H.*

450. *Primary form:* a right rhombic prism; M : M=112° 37′. *Secondary form:* a figure of a crystal from Elba. In other crystals the plane a, is wanting; a : o=158° 49′, o : o=139° 37′, M : o=128° 38′. Lateral faces usually longitudinally striated. *Cleavage* parallel to c̄, indistinct. It occurs also massive, columnar, and granular. When the latter, the structure is often nearly impalpable.



H.=5·5—6. G.=3·8—4·1; 3·994, Haidinger; 3·9796, Stromeyer; 3·825—4·061, Lelievre. *Lustre* submetallic. *Streak* black, inclining to green, or brown. *Color* iron-black, or dark grayish-black. Opaque. *Fracture* uneven. Brittle.

It contains, according to Vauquelin (Jour. des Mines, xxi. 70) and Stromeyer, (Untersuchungen, p. 374,)

	Elba.	Elba.
Silica	29	29·278
Lime	12	13·779
Protoxyd of Iron	} 57	52·542
Protoxyd of Manganese		1·587
Alumina	—	0·614
Water	—=98, Vauq.	1·268=99·068, Strom.

Before the blowpipe, on charcoal, it fuses into a black globule, which becomes vitreous in the external flame. In the interior flame the surface becomes dull, and provided the globule has not been heated to redness, it is attractable by the magnet. With borax and carbonate of soda, it fuses into glass, nearly or perfctly black. It is soluble in muriatic acid.

Obs. This mineral was first discovered on the Rio la Marina, in Elba, by M. Lelievre, in 1802, where it occurs in solitary crystals of considerable dimensions, and aggregated crystallizations in compact augite. It has also been observed at Fassan, in Norway, in Siberia, and Silesia.

At Cumberland, R. I., it occurs in long slender black or brownish-black crystals, traversing quartz, and associated with magnetic iron ore and hornblende. The name *Lievrite* was given this mineral in compliment to its discoverer; *Ilvaite* is derived from the name of the island, Elba, on which it was first found; Yenite, or Jenite, was applied by the French in commemoration of the battle of Jena, in 1806.

BROWN IRON ORE. SIDERUS HÆMATICUS.

Prismatic Iron Ore, *M.* and *J.* Brown Hematite. Brown Iron Ore. Hydrous Peroxyd of Iron. Stilpnosiderite. Brown Ochre. Brown Clay. Iron Stone. Bog Iron Ore. Göthite. Pyrosiderite. Onegite. Yellow Clay Iron Stone. Rubinglimmer. Brauneisenstein, Thoneisenstein, *W.* Eisenoxyd-Hydrat, *L.* Fer Oxyde, *H.* Fer Hydro-Oxide, *Levy.*

451. *Primary form:* a right rhombic prism; M : M=130° 40′. *Cleavage* parallel to ĕ, or the shorter diagonal. Perfect crystals are of rare occurrence. This species usually presents stalactitic and botryoidal, or mammillary forms, having a fibrous structure; also massive, and occasionally earthy. Pseudomorphs, imitative of calcareous spar and iron pyrites, have been observed.

H.=5—5·5. G.=3·922, Haidinger; 4·04, crystals from St. Just. *Lustre* adamantine, submetallic; sometimes dull and earthy. *Streak* yellowish-brown. *Color* various shades of brown, commonly dark, and none bright. Crystals often subtransparent, and exhibiting a blood-red tint; in crystallized varieties, opaque.

It contains, according to Thomson, Ulmann, and D'Aubuisson,

	Crystals.	Stilpnosiderite.	Hematite.	Brown Ochre.
Peroxyd of Iron	91·7	80·50	79	83
Water	8·5	16·00	15	12
Silica	—	2·25	2	5
Sesquoxyd of Manganese	—	trace	3	trace
	100·2, Th.	98·75, Ul.	99, D'A.	100, D'A.

Dr. Thomson supposes the crystals form a distinct species; they contain but half an atom of water, instead of one, as in the ordinary brown hematite, and is therefore a dihydrate of iron, whereas the latter is a simple hydrate.

Before the blowpipe it blackens and becomes magnetic; with borax it fuses into a green or yellow glass. It dissolves in warm nitro-muriatic acid, and gives out water when heated in a matrass.

Obs. This species is very varying in its external appearance, and as abundant in the appellations by which it has been designated. The crystallized variety has been called *Onegite*, *rubinglimmer*, *pyrosiderite*, and *Göthite;* the first from its locality, the last in compliment to the celebrated poet and mineralogist, Göthe. *Brown hematite* includes the ordinary imitative shapes. *Scaly* and *ochrey brown iron ore*, are more or less decomposed varieties, composed of slightly cohering particles. *Bog iron ore* arises from the decomposition of other species, and occurs in low marshy grounds. The pisiform and reniform clay iron ores, consist of concentric globular concretions, imbedded either in friable or compact brown hematite.

Brown iron ore occurs both in primitive and secondary rocks, in beds and veins, associated at times with spathic iron, heavy spar, calcareous spar, Arragonite, and quartz; and more particularly when in veins, it is often associated with ores of manganese.

The crystallized variety occurs in the cavities of sandstone, at Clifton, near Bristol; near Lostwithiel, in Cornwall, and at Lake Onega, in Siberia. Other varieties occur in Cornwall, at Clifton, at Sandloge in Shetland, in Carinthia and Bohemia, at Siegen near Bonn, and at Villa Rica, in Brazil. The bog ore forms considerable repositories in Germany, Poland, and Russia.

Extensive beds of brown iron ore, accompanied by the ochrey iron ore, exist at Salisbury and Kent, Conn., in mica slate; also in the neighboring towns of Beekman and Amenia, N. Y., and in a similar situation north at Richmond and Lenox, Mass. At Hinsdale it is the cement in a conglomerate quartz rock. It is very abundant at Bennington, Vt., also at Monkton, Pittsford, Putney, and Ripton, of the same state. Nantucket and Martha's Vineyard are other localities; also near Tinder's Gold Mine, Louisa Co., Va., there is an abundant deposit. The argillaceous varieties are abundant in Pennsylvania, near Easton, and through the Lehigh range in Fayette Co., at Armstrong, Upper Dublin, and in Washington Co. In nodules, from one inch to a foot in diameter, it is met with at Bladensburg, Maryland; also in gravel hills, near Marietta, in Ohio. An argillaceous ore is also found on Mount Alto, in the Blue Ridge, in Shenandoah Co., Va., and in Chatham and Nash Co., N. C.

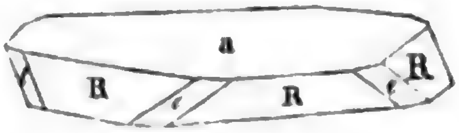
Brown iron ore is one of the most important ores of iron. The pig iron, from the purer varieties, obtained by smelting with charcoal, is readily convertible into steel. That yielded by bog ore, is what is termed *cold short*, and cannot therefore be employed in the manufacture of wire, or even of sheet-iron, but is valuable for casting. The hard and compact nodular varieties are employed in polishing metallic buttons, &c.

SPECULAR IRON. Siderus rhombohedrus.

Rhombohedral Iron Ore, *M.* Rhomboidal Iron Ore, *J.* Red Iron Ore. Oligiste Iron. Micaceous Iron Ore. Red Hematite. Red Clay Ironstone. Red Ochre. Iron Foam. Eisen Glanz, Rotheisenstein, *W.* Blutstein, *Haus.* Eisenoxyd, *L.* Fer Oligiste, *H.*

452. *Primary form:* an acute rhombohedron; R : R=85° 58′, and 94° 2′. *Secondary forms:* figs. 1 and 2, of a crystal from Vesuvius; fig. 3, a crystal from Elba.

1.



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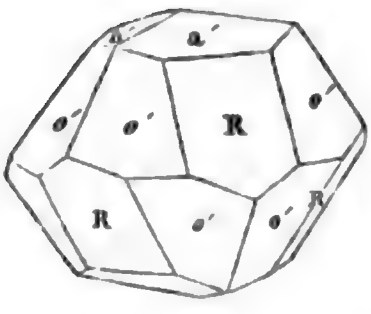

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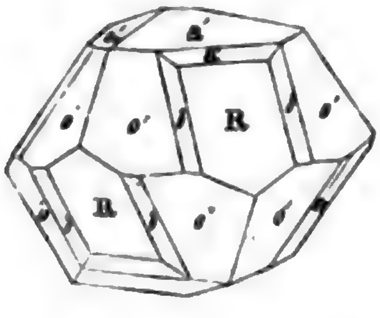


R : *e*=137° 1′, *o′* : *o′*=128° and 122° 29′, R : *o′*=151° 14′, a′ : a′=142° 56′. *Cleavage* parallel to a and R; often indistinct. *Com-*

pound crystals. Composition of the first kind or parallel to **R**; also of the third kind, in which it takes place parallel to a, the truncating plane of the vertical angle. *Imperfect crystallizations:* structure columnar—globular, reniform, botryoidal, and stalactitic shapes, and also amorphous; structure lamellar—laminæ joined parallel to a, and variously bent—thick or thin; structure granular—particles often nearly impalpable—slightly coherent—at other times strongly coherent; pseudomorphs occur, imitative of calcareous spar, fluor spar, &c.

H.=5·5—6·5. G.=4·5—5·3. Some compact varieties are as low as 4·2. *Lustre* metallic and occasionally splendent—massive varieties sometimes earthy. *Streak* cherry-red or reddish-brown. *Color* dark steel-gray or iron black; impure varieties, red and unmetallic. Opaque, except when in very thin laminæ, which are faintly translucent and of a blood-red tinge. *Fracture* sub-conchoidal, uneven. Sometimes it is slightly attractable by the magnet; the volcanic varieties occasionally exhibit polarity.

It contains, when pure, 69·34 of Iron, and 30·60 of Oxygen, being a pure peroxyd of iron. D'Aubuisson found red hematite to contain Peroxyd of Iron 94, Silica 2·0, Lime 1·0, Water 3. Dr. Henry found in *Iron froth*, Peroxyd of Iron 94·5, Silica ? 4·25, Alumina 1·25.

It is infusible, *per se*, before the blowpipe; with borax it fuses into a green or yellow glass. It dissolves in heated muriatic acid.

Obs. This species includes the old species, specular iron and red iron ore, which are identical in chemical composition, and differ only in the state of aggregation of the particles. *Specular iron* includes the varieties of a perfect metallic lustre; if the structure is micaceous, it is the *micaceous specular iron.* The varieties of a sub-metallic or non-metallic lustre, were included under the name of *red hematite*, *fibrous red iron*, or if consisting of impalpable weakly coherent particles, *red ochre*, and when of slightly coherent scales, *scaly red iron*, or *red iron froth.* Under this species must also be included the different clay iron ores, many of which contain but small portions of iron; *reddle* or *red chalk*, the common drawing material, which has an earthy appearance and a flat conchoidal fracture; *jaspery clay iron*, more firm in its structure than the preceding, and having a large and flat conchoidal fracture; *columnar* and *lenticular clay iron*, distinguished by their columnar or flattish granular structure. Specular iron occurs most commonly in primitive rocks; it also occurs among the ejected lavas of Vesuvius. The argillaceous ores form beds in secondary rocks.

The most magnificent specimens of this species are brought from the island of Elba, which has afforded it from a very remote period, and is described by Ovid, as the "Insula inexhaustis chalybdum generosa metallis." The surfaces of the crystals often present a very splendid irised tarnish, and, connected with the most brilliant lustre, they are among the finest objects in the cabinet of the mineralogist. The faces a and a′ are usually destitute of this tarnish and lustre, and may therefore assist, when present, in determining the situation of other planes when the crystal is quite complex. St. Gothard affords very beautiful specimens, composed of crystallized plates grouped together in the form of rosettes, and accompanying crystals of feldspar. Fine crystallizations are the result of volcanic action at Etna and Vesuvius, and particularly in Fossa Kankarone, on Monte Somma, where it forms crystalline incrustations on the ejected lavas. Arendal, in Norway, Langbanshyttan, in Sweden, Framont, in Lorraine, Dauphiny, and Switzerland, also afford splendid specimens of specular iron. Red hematite occurs in reniform masses of a fibrous concentric structure, near Ulverstone in Lancashire, in Saxony, Bohemia, and the Hartz. In Westphalia, it occurs as pseudomorphs of calcareous spar. Iron mica comes principally from Cattas Atlas, in the Brazils.

Handsome irisedly tarnished crystallizations of specular iron are found at Fowler, St. Lawrence Co., N. Y., in cavities in granular micaceous iron ore, and associated often with splendid groups of quartz crystals presenting the form of the isosceles dodecahedron. Uncrystallized metallic varieties are common in other parts of the same country. It occurs also in the Blue Ridge, in the western part of Orange Co., Va. Micaceous iron in large masses, composed of irregular curved laminæ, occurs at Hawley, Mass.; also eight miles above Falmouth, Stafford Co., Va., on the Rappahannock river. Red hematite is found at Ticonderoga, upon Lake George. Lenticular argillaceous ore is abundant at Utica and Clinton. At these places it forms a layer about a foot thick in a fine silicious gray-wacke, and extends west, of the same thickness, to the west end of Lake Ontario. The layer, according to Eaton, is about twenty miles wide and two hundred and forty miles long.

This ore affords a considerable portion of the iron manufactured in different countries. These varieties, especially the specular, require a greater degree of heat than other ores, but the iron obtained is nevertheless of good quality. Pulverized red hematite is employed in polishing metals, and also is a coloring material. Specular iron is readily distinguished from magnetic iron ore, by it reddish streak.

Hematite, a word in use among the ancients, was applied to this and the preceding species on account of the red color of the powder, from *αἷμα*, *blood*. The term *specular*, alludes to the brilliant lustre it often presents.

MAGNETIC IRON ORE. SIDERUS OCTAHEDRUS.

Octahedral Iron Ore, *M.* Oxydulated Iron. Ferroso-ferric Oxyd. Manganeisenstein, *of the Germans.* Fer Oxydulé, *H.*

453. *Primary form:* the regular octahedron. *Secondary forms:* most of the forms represented in the first twenty figures of Pl. I.; also fig. 25, Pl. I. *Cleavage* parallel to the primary form; perfect—imperfect. The dodecahedral faces are commonly striated parallel to the longer diagonal. *Compound crystals:* fig. 129, Pl. II.; also the same kind of composition with the secondary modifications. *Imperfect crystallizations:* structure granular—particles of various sizes, sometimes impalpable.

H.=5·5—6·5. G.=6·094. *Lustre* metallic—submetallic. *Streak* black. *Color* iron-black. Opaque. *Fracture* subchonchoidal, shining. Brittle. Strongly attracted by the magnet, and sometimes possessing polarity.

It is composed, as determined by Berzelius, of two atoms of peroxyd of iron, and one of protoxyd. Before the blowpipe it becomes brown, and loses its influence on the magnet; but it does not fuse. With borax, in the oxydizing flame, it fuses into a dull-red glass, which becomes clear on cooling, and often assumes a yellow tint; in the reducing flame it becomes bottle-green. It dissolves in heated muriatic acid, but not in nitric acid.

OBS. Magnetic iron ore occurs in beds, in primitive rocks, generally in gneiss; but also in clay slate, hornblende slate, chlorite slate, greenstone, and occasionally in limestone.

The beds of ore at Arendal, and nearly all the celebrated iron mines of Sweden, consist of massive magnetic iron. Dannemora, and the Täberg, in Smäland, are entirely formed of it. Still larger mountains of it exist at Kurunavara and Gellivara, in Lapland. Fahlun in Sweden, and Corsica, afford octahedral crystals, imbedded in chlorite slate. Splendid dodecahedral crystals occur at Normark, in Wermeland. The most powerful native magnets are found in Siberia, in the Hartz. They are also obtained on the island of Elba.

Very extensive beds of this ore occur at different places upon the western side of Lake Champlain, and in the Highlands of New York; also in the mountainous districts of New Jersey and Pennsylvania, and on the eastern side of Willis Mountain, in Buckingham Co., Virginia, &c. Dodecahedral crystals occur at Franconia, N. H., imbedded in epidote and quartz. At Marlborough, Vt., it is found in octahedral crystals, imbedded in chlorite, and at Bridgewater, Vt., in chlorite slate.

The black streak of this species distinguishes it from other ores of iron.

FRANKLINITE. SIDERUS ZINCIFERUS.

Dodecahedral Iron Ore, *M.*

454. *Primary form:* the regular octahedron. *Secondary forms:* fig. 9, and others, Pl. 1. *Cleavage* very indistinct parallel to the primary planes. It occurs also massive, with a coarse or fine granular structure—particles strongly coherent.

H.=5·5—6·5. G.=5·069, Thomson; 5·091, Haidinger; 4·87, Berthier. *Lustre* metallic. *Streak* dark reddish-brown. *Color* iron-black. Opaque. *Fracture* conchoidal. Brittle. Acts slightly on the magnet.

It contains, according to Berthier and Thomson,

Peroxyd of Iron	66	66·100
Sesquoxyd of Manganese	16	14·960
Oxyd of Zinc	17	17·425
Silica	—	0·204
Water,	— =99, B.	0·560=99·249, T.

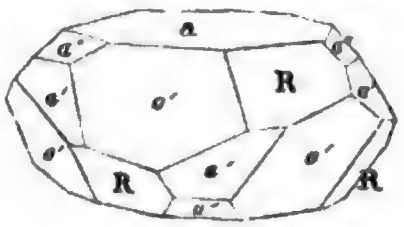
At a high temperature zinc is driven off. It dissolves without effervescence in heated muriatic acid.

OBS. Franklinite is stated to occur in amorphous masses at the mines of Altenberg, near Aix la Chapelle. But a more abundant locality is at Franklin furnace, in Hamburg, N. J., where it is accompanied by red oxyd of zinc and garnet, in calcareous spar. The most perfect crystals are imbedded in red zinc ore; those occurring in calc spar have their angles rounded. A still more remarkable deposit exists at Sterling, in the same region, where it is associated with Troostite, in a powerful vein, in which cavities occasionally contain crystals from one to three inches in diameter.

CRICHTONITE. SIDERUS ACROTOMUS.

Axotomous Iron Ore, *M.* Iserine. Ilmenite. Menaccanite.

455. *Primary form:* an acute rhombohedron; R : R=61° 20′. *Secondary form:* the annexed figure. *Cleavage* parallel to the plane a, which truncates the vertical solid angle. Commonly in angular grains, and irregular masses; sometimes forming a coating on other species.



H.=5—5·5. G.=4·4—4·8; 4·427—4·491, Thomson; 4·5—4·650, Klaproth. *Lustre* submetallic. *Streak* metallic. *Color* dark iron-black. Opaque. *Fracture* conchoidal. Slightly affects the magnetic needle.

It contains, according to Mosander, Rose, and Kobell,

	Miask.		Gastein.
Titanic Acid	46·67	50·12	59·00
Oxyd of Iron	47·08	49·88	40·25
Oxyd of Manganese	2·39	—	1·65
Magnesia	0·60	—	—
Lime	0·25	—	—
Oxyd of Chrome	0·38	—	—
Silica	2·80=100·17, M.	— =100, R.	— =100·90, K.

It is infusible, *per se*, before the blowpipe; with fluxes its action is similar to that of oxyd of iron. It is readily soluble in concentrated muriatic acid.

Obs. The variety Menaccanite occurs in irregular crystals and masses, imbedded in serpentine at Inglesberg, in the valley of Gastein, Saltzburg, and is associated with apatite and sparry iron ore. At Eggersend, in Norway, it occurs massive and compact, and imperfectly crystallized at Ilmensee and Ekatherinenberg, in Siberia. It was first observed near Menaccan, Cornwall. The name *Iserine* is derived from the river Iser, in Bohemia, where it occurs in rolled masses. It occasionally forms a coating on rutile, and is sometimes mistaken for nigrine, a variety of rutile; but it is distinguished by its inferior hardness and black streak. At Amity, N. Y., it occurs in black crystals, imbedded in serpentine, and white limestone, and associated with spinel, Brucite, rutile, &c. It also occurs in broad laminated masses at Washington, Conn., imbedded in a vein of quartz, traversing primitive rocks.

Crichtonite is sometimes made a distinct species, separate from the other varieties of this species; but its distinctness has not yet been proved by an analysis, or by crystallographic considerations. It is described as having a brilliant metallic lustre, and occurring in small acute rhombohedrons, with truncated vertical solid angles. With salt of phosphorus it affords a glass which becomes red on cooling. Its only locality is St. Christophe, near Oisians in the department of the Isère, where it occurs with anatase, quartz, and chlorite.

Another titanate of iron has been analyzed by Berthier, and found to contain Titanic Acid 41, Peroxyd of Iron 56·2, Quartz 2·5=99·7, with a trace of Oxyd of Manganese. It occurs in dark gray compact granular masses, with little or no lustre, in Brazil, where, according to M. Montlevade, it constitutes mountains or thick banks of considerable extent, alternating with transition rocks.

MOHSITE. Siderus Mohsianus.

Levy, Ann. of Phil. March, 1827.

456. *Primary form:* an acute rhombohedron; R : R=73° 43′. Occurs mostly in compound crystals, in the form of flat and nearly circular crystals, with alternate re-entering and salient angles on their edges. *Cleavage* not apparent.

Scratches glass. *Lustre* metallic; brilliant. *Color* iron-black. Opaque.

Obs. It is supposed to have come from Dauphiny, It is distinguished from the preceding species by the indistinctness of its cleavage, and its superior hardness. It was named Mohsite by Mr. Levy, in honor of the very distinguished mineralogist, Professor Mohs.

BREISLAKITE.

457. Occurs in delicate capillary crystals of a reddish-brown or chesnut-brown color, bent and grouped like wool; fibres flexible. *Lustre* metallic.

It contains Silica, Alumina, Iron, and a considerable portion of Copper. With salt of phosphorus it affords a green globule, which is red in the reducing flame.

Obs. It forms coatings in the cavities of lavas, and accompanies nepheline and pyroxene. It has been observed at Vesuvius and Capo di Bove, near Rome.

ORDER VIII.—METALLINEA.

IRON. FERRUM OCTAHEDRUM.

Octahedral Iron, *M.* and *J.* Meteoric Iron. Gedlegen Eisen, *W.* and *L.* Fer Natif, *H.* Mars, *Alchem.*

458. *Primary form:* the regular octahedron. *Cleavage* apparent parallel to the faces of the octahedron.

H.=4·5. G.=7·3—7·8; 7·318, a partially oxydized fragment of a crystal from Guilford Co., N. C. *Lustre* metallic. *Color* iron-gray. *Streak* shining. *Fracture* hackly. Ductile. Acts strongly on the magnet.

Native iron, undoubtedly of terrestrial origin, has been observed at Canaan, Conn., and in Guilford Co., N. C. At the former place it occurred in the form of a vein, or plate, two inches thick, attached to a mass of mica slate rock; at the latter locality was found an octahedral crystal weighing about 7 ounces, which is reported to have been detached from a mass weighing 28 pounds, and which a blacksmith wrought into nails. These specimens are now in the Yale College cabinet.

Foreign specimens are also reported to have been found. Cramer describes one weighing 4 pounds, obtained in the mine of Hackenburg. Other Saxon localities are Steinbach and Eibestock.

Meteoric iron usually contains nickel, and small quantities of other metals.

The following analyses of meteoric iron have been lately published by Berzelius, in Kongl. Vet. Acad. Handlingar. Stockh. 1834, p. 115.

	From Blansko.	From Siberia.		From Elnbogen.
Iron	93·816	88·042		88·231
Nickel	5·053	10·732		8·517
Cobalt	0·347	0·455		0·762
Manganese	——	0·132	Sulphur and Mang.	trace
Tin and Copper	0·460	0·066		——
Sulphur	0·324	trace		——
Phosphorus	trace	——	Metallic Phosphurets	2·211
Magnesium	——	0·050		0·279
Carbon	——	0·043		——
Insoluble part	—— =100.	0·480=100.		—— =100.

The *first* specimen fell near Blansko, on the 25th November, 1833. The metallic iron constituted only ·1715 part of it. The *second* was discovered by Pallas on a mountain, between Krasnojarsk and Abekansk, in Siberia. It contained imbedded olivine. The *third* specimen is supposed to have fallen towards the close of the fourteenth century; it is preserved at Vienna.

One of the most extraordinary of these iron meteorites, preserved in any collection, is now in the Yale College cabinet. It weighs 1635 lbs.; length 3 feet 4 inches; breadth 2 feet 4 inches; height 1 foot 4 inches. It has been analyzed by C. U. Shepard, (Silliman's Amer. Jour. XVI. 217,) and found to contain Iron 90·02, Nickel

9·674=99·694. It was brought from Red river. Still more remarkable masses exist in South America; one was discovered by Don Rubin de Celis, in the district of Chaco-Gualamba, whose weight was estimated at 30,000 pounds; and another was found at Bahia, in Brazil, whose solid contents are at least 28 cubic feet, and weight 14,000 pounds. The Siberian meteorite, discovered by Pallas, weighed originally 1600 pounds, and contained imbedded crystals of chrysolite. Smaller masses are quite common. Meteoric iron is perfectly malleable, and is readily worked into cutting instruments, and may be put to the same uses as manufactured iron.

PLATINUM. Platinum cubicum.

Native Platina, *M.* and *J.* Hexahedral Platina, *Haid.* Platina. Gedlegen Platina, *W.* and *L.* Polyxen, *Haus.* Platine Natif Ferrifère, *H.*

459. *Primary form :* the cube. In irregular forms and grains. *Cleavage* none.

H.=4—4·5. G.=16—19 ; 17·332 is the average or most usual specific gravity. *Lustre* metallic. *Streak* and *color* perfect steel-gray ; shining. Opaque. Ductile. *Fracture* hackly.

It contains, according to Berzelius, (Kong. Vet. Acad. Handl., 1828, p. 113,)

	Nischne Taglisk.	Nischne Taglisk.	Goroblagodat.
Platinum	78·94	73·58	86·50
Iridium	4·97	2·35	——
Rhodium	0·86	1·15	1·15
Palladium	0·28	0·30	1·10
Copper	0·70	5·20	0·45
Iron	11·04	12·98	8·32
Osmium and Iridium	1·96	undetermined 2·30	1·40
	98·75	97·86	98·92

It is soluble only in heated nitro-muriatic acid. Not fusible in the flame of the common blowpipe. It acts slightly on the magnet; this property depends on the amount of iron it contains.

Obs. Platinum was first found in pebbles and small grains, associated with iridium, rhodium, osmium, palladium, gold, copper, and chrome, in the alluvial deposits of Brazil, Choco, and Barbacoa, in South America, where it received its name, *platina*, from *plata, silver*, of which word platina is a diminutive. It has of late years been discovered in considerable abundance at Nischne Tagilsk, and Goroblagodat, in the Uralian mountains, and has been formed into coins by the Russians. They are not a legal tender, but pass conventionally, and are principally current in the southern provinces of the empire.

Although platinum generally occurs in quite small grains, masses are sometimes found of considerable magnitude. A mass, weighing 1088 grains, was brought by Humboldt from South America, and deposited in the Berlin museum. Its specific gravity was 18·94. In the year 1822 a mass of platinum from Condoto was deposited in the Madrid museum, measuring two inches and four lines in diameter, and weighing 11,641 grains. A still more remarkable specimen was found in the year 1827, in the Ural, not far from the Demidoff mines, which weighed $10\frac{44}{96}$ Russian pounds, or 9·522 lbs. avoirdupois. It specific gravity was 16.

The infusibility of this metal, and its property of resisting the action of air and moisture, and nearly all chemical agents, render it highly valuable for the construction of philosophical and chemical apparatus. The vessels employed in the concentration of sulphuric acid are now made of platinum, which is unaffected by an acid generally so corrosive. Platinum is also employed for covering other metals, and for painting on porcelain. It admits of being drawn into wire of extreme tenuity. Dr. Wollaston succeeded in obtaining a wire not exceeding the two thousandth part of an inch in diameter.

IRIDIUM. IRIDIUM HEXAGONUM.

Rhombohedral Iridium, *Haid.* Native Iridium. Iridosmine. Alloy of Iridium and Osmium.

460. *Primary form:* a hexagonal prism. *Secondary form:* fig. 125, Pl. II. *Cleavage* parallel with P, easily obtained; parallel with M, indistinct. Commonly in irregularly flattened grains.

H.=6—7. G.=19·5, Wollaston; 19·471, Rose, a crystal at 52°; 21·118, a crystal from Nischne Tagilsk, in Siberia. *Lustre* metallic. *Color* tin-white, and light steel-gray. Opaque. Malleable with difficulty.

There are three or four distinct varieties of this species, which have been described by Berzelius as occurring in Siberia, (Pogg. Ann. xxxii.) The first consists of flat plates, possessing no regular form, and a hardness sufficient to scratch glass. G.=19·25. They contain, according to Berzelius, Iridium 46·77, Osmium 49·34, Rhodium 3·15, Iron 0·74, which is nearly equivalent to an atom each of Iridium and Osmium.

The second variety is found in plates. G.=18·645—19·25.

The remaining varieties occur in six sided plates. G.=21·118. One contains Iridium 25·1, and Osmium 74·9, or one atom of the former to three of the latter; the other, Iridium 20, and Osmium 80, or one atom of Iridium to four of Osmium.

At a high temperature some of these varieties give out a little osmium, but undergo no further change. With nitre, the characteristic odor of osmium is soon afforded, and a mass obtained soluble in water, from which a green precipitate is thrown down by nitric acid.

OBS. It occurs with platinum in the province of Choco, in South America, and in the Ural mountains. It was first distinguished by Dr. Wollaston, who discovered that the specimens were an alloy of iridium and osmium.

PALLADIUM. PALLADIUM OCTAHEDRUM.

Octahedral Palladium, *Haid.* Native Palladium.

461. *Primary form:* supposed to be the regular octahedron. Occurs mostly in grains apparently composed of diverging fibres.

H. above 4·5. G.=11·8, Wollaston; 12·14, Lowry. *Lustre* metallic. *Color* steel-gray, inclining to silver white. Opaque. Ductile and malleable.

It consists of palladium, alloyed with a little platinum and iridium. It is infusible, *per se*, before the blowpipe, but it fuses readily with sulphur. By continuing the heat, the sulphur is driven off, and a globule of palladium obtained.

OBS. Palladium occurs with platinum, in Brazil. Its divergent structure distinguishes it from the latter metal. It was first made known by Wollaston.

SELENPALLADITE. PALLADIUM RHOMBICUM.

Seleniet of Palladium.

462. *Primary form:* a hexagonal prism. Occurs in six sided tables, which have a foliated structure, and cleave parallel to the base of the prism.

Lustre metallic. *Color* white—grayish-white. Opaque. Brittle. If heated in a tube, it gives a red ring of selenium. Heated strongly before the blowpipe it becomes colored, and fuses into a brittle metallic globule; with borax it forms a transparent glass.

Obs. It exists in considerable quantities at Tilkerode, in the Duchy of Anhalt-Bernborg, in the Hartz, associated with selenid of lead and native gold, where it was first detected by M. Zinken.

GOLD. Aurum cubicum.

Hexahedral Gold, *M.* Native Gold. Gediegen Gold, *W.* Electrum, *Haus.* Or Natif, *H.* Sol. *Alchym.* Rex Metallorum.

463. *Primary form:* the cube. *Secondary form:* figs. 2—11, inclusive, of Pl. I., also figs. 14, 15, 16. *Cleavage* none. *Compound crystals:* composition similar to that represented in fig. 129, but occurring in the form exhibited in fig. 16, Pl. I., or the tetragonal trisoctahedron. *Imperfect crystallizations:* filiform, reticulated and arborescent shapes—also in thin laminæ; also in imbedded grains and rolled masses.

H.=2·5—3. G.=12—20. *Lustre* metallic. *Streak* and *Color* various shades of gold yellow, sometimes inclining to silver-white. Opaque. Very ductile and malleable.

The ores of gold in nature, usually contain silver in different proportions. The largest proportion of silver is found in the *electrum* of Klaproth, which is composed of Gold 64, and Silver 36, or two of gold to one atom of silver.

Obs. The native gold of Marmato, is composed of Gold 73·45, Silver 26·48, or 3 parts of gold to 1 of silver. Its specific gravity is only 12·666, as determined by Boussingault. The proportion of 3½ : 1 has been found by Rose in the gold of Titiribi, in Columbia; that of 5 : 1 by Boussingault in gold from Trinidad; 6 : 1 by Boussingault in specimens from Ojas Anchas, and by Rose in specimens from near Nischne Tagilsk, in Siberia, and St. Barbara, Transylvania. The proportion of 8 : 1 is the most abundant; such is the case in a specimen from Gozuschka, Nischne Tagilsk, which Rose found to contain 87·17 of Gold, and 12·41 of Silver; also in numerous others analyzed by the same chemist, and also by Boussingault. That of 12 : 1 is also of frequent occurrence. Boussingault found a specimen from St. Bartholomé to contain Gold 91·9, and Silver 8·1; another from Girar to be composed of Gold 91·9, and Silver 8; in each of which, the proportion of gold to silver is that last stated. A similar composition was found by Rose, in specimens from different localities; one from Boruschka contained Gold 91·36, and Silver 8·38. The least quantity of silver was found by G. Rose, in the native gold of Schabrowski, near Catharinenburg, in Siberia. It was composed of Gold 98·96, Silver 0·16, Copper 0·35, Iron 0·05=99·52. Its specific gravity was 19·099. Copper is also occasionally alloyed with gold.

It also occurs disseminated in grains or thin leaves in various metallic minerals, particularly iron pyrites.

Native gold occurs in veins, and in interspersed grains and laminæ, and occasionally crystallized, in quartz. In the United States, this quartz gangue forms beds in the mica slate of the region. Occasionally the mica slate has a talcose character. It is often found in the sands of rivers, and valleys, where it has been carried from the disintegration of auriferous rocks. Such is its mode of occurrence in Brazil, Mexico, and Peru, in which countries it is occasionally met with in masses of several pounds weight. Masses weighing even sixteen pounds have been discovered in the Ural, where the gold occurs in a similar situation. In Transylvania, a considerable quantity of gold is obtained from stream works. It is met with in alluvial soil, in the

Wicklow mountains of Ireland, and at Leadhills, in Scotland. A specimen, weighing nearly eight sovereigns, from the Breadalbane estate, near Glen Coich, in Perthshire, is now in the mineralogical cabinet of Mr. Allan, of Edinburgh. At Vorospatak, in Transylvania, the gold is disseminated in grains through the rock. The mines of Hungary and Transylvania, Kremnitz, Schemnitz, Posing, Botza, Magurka, Nagyag, Offenbanya, and Boitza, occasionally afford fine specimens of this metal. It occurs also in Salzburg, and thence in several places along the Alps, as far as La Gardette, near Allemont, in Dauphiny. The Russian mines, in the Uralian mountains, are quite productive.

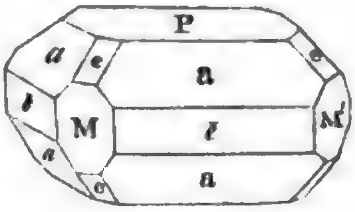
The mines in the United States are quite as promising as any in the world. The principal deposits of gold, at present discovered, are situated within the states of Georgia, the Carolinas, and Virginia; but it has been traced as far north as the Chaudière river, in Lower Canada, and is believed to occur in a nearly continuous line from the Rappahanock, in Virginia, to the Coosa, in Alabama. The mines in North Carolina are mostly within the three ranges of counties between Frederick and Charlotte, which are situated about in a line running N. E. and S. W., corresponding in general with the direction of the coast. The mines at Mecklenburg, which are principally vein deposits, are the most valuable. The mines of Burke, Lincoln, and Rutherford, are for the most part in alluvial soil. Splendid specimens have occasionally been found, the most magnificent of which was discovered in Cabarras county; it weighed twenty eight pounds. In Virginia, valuable deposits occur in Spotsylvania Co., ten miles above Fredericksburg, on the Rappahanock river, at the U. S. gold mines; accompanying silver, lead, and Vivianite, at Rappahanock gold mines, Stafford Co., ten miles from Falmouth; in quartz and decomposed pyrites, at the Culpepper mines, Culpepper Co., on Rapidan river; in auriferous pyrites distributed through veins of quartz, lying in hornblende slate, at Orange grove gold mine, Orange Co.; in quartz, and also in alluvial deposits, at the Greenwood gold mines, Orange Co.; in beds of quartz, from one to two feet thick, associated with iron pyrites, copper pyrites, blende, argentiferous galena, spathic iron, and Anglesite, at Walton's gold mine, Louisa Co. About $100,000 have been obtained by washing along the streams in the vicinity of this mine. It accompanies granular heavy spar, in auriferous pyrites, at Eldridge's mine, in Buckingham Co., and occurs in various other parts of the state.

Gold is the most ductile and malleable of the metals. According to Dr. Ure, a grain may be made to cover in the form of gold leaf, 56¾ square inches; and Reaumur states, that a grain, extended to the thinness it has upon gilt silver wire, will cover an area of 1400 inches. The thinnest gold leaf is the 280 thousandth part of an inch thick. On account of the extreme malleability of this metal, though costly, it is one of the most common and cheapest means of ornamenting furniture, &c. It retains its perfect brightness of lustre uninfluenced by moisture and the atmosphere, and for this reason is perfectly fitted for its various ornamental uses, and also for numerous purposes in the arts.

The name *electrum*, was applied by the ancients to an alloy of silver and gold, in the proportion of one to five. This is the origin of Klaproth's name for a similar native alloy.

AURO-TELLURITE. AURUM RHOMBICUM.

Yellow Ore of Tellurium. White Ore of Tellurium.



464. *Primary form:* a right rhombic prism. *Secondary form:* M : $\bar{e}$=142° 45′, M : $\breve{e}$=127° 15′, P : a=108° 30′, P : *a*=143° 5′. *Cleavage* in traces. Occurs in small crystals and imbedded crystalline laminæ.

Soft. G.=10·678, Muller von Reichenstein. *Lustre* metallic. *Color* silver-white, much inclining to brass-yellow. Opaque. Rather brittle.

According to Klaproth, (Beitrage, iii. 28,) it contains Tellurium 44·75, Gold 26·75, Silver 8·50, Lead 19·50, Sulphur 0·50. Before the blowpipe it fuses into a metallic globule, and gives out a pungent odor. It is soluble in nitric acid.

Obs. Its only known locality is at Nagyag, in Transylvania, where it is associated with graphic gold and manganblende.

SILVER. Argentum octahedrum.

Hexahedral Silver, *M.* and *J.* Native Silver. Gediegen Silber, *W.* Argent Natif, *H.*

465. *Primary form:* the regular octahedron. *Secondary forms:* figs. 2, 3, 4, 16, and others intermediate, Pl. I. *Cleavage* none. *Compound crystals:* fig. 129, Pl. II. *Imperfect crystallizations:* coarse and fine filiform, reticulated and arborescent shapes; also in plates, and in superficial coatings.

H.=2·5—3. G.=10·4743, Haüy; 10·338, Gellert. *Lustre* metallic. *Streak* shining, metallic. *Color* silver-white; subject to tarnish, by which the color becomes a grayish-black. Ductile.

Native silver is usually an alloy of silver and copper. The composition, according to Berthier, of a specimen from Carey, is Silver 90, and Copper 10. It is also combined with gold in various proportions, as is stated under gold. Fordyce obtained from an alloy of this kind, Silver 72, and Gold 28; and Klaproth, from another ore, obtained Silver 36, and Gold 54. Probably several of the compounds of gold and silver will constitute distinct species, when their peculiarities shall have been more studied. It fuses readily in the blowpipe flame, and affords on cooling a globule, having an angular crystalline form. It dissolves in nitric acid and heated sulphuric acid.

Obs. Native silver occurs principally in arborescences and filiform shapes, in veins of calcareous spar or quartz, traversing gneiss slate, and other primitive rocks. The structure of these forms is sometimes quite peculiar; they being composed of one or more series of octahedrons, either closely united or arranged perpendicularly in straight rows. This structure is very apparent in most of the Norwegian and Mexican varieties.

The mines of Kongsberg, in Norway, formerly afforded magnificent specimens of native silver; they are now, however, for the most part, under water. One specimen among the splendid suite from this locality, in the royal collection at Copenhagen, weighs upwards of 5 cwt. Its principal Saxon localities are at Frieberg, Schneeberg, and Johanngeorgenstadt; its Bohemian, at Przibram, Jochimstahl, and Ratiborzitz. It also occurs in small quantities with other ores at Andreasberg, in the Hartz, in Suabia, Hungary, at Allemont, in Dauphiny, and in some of the Cornish mines. A mine on the estate of Alva, in Stirlingshire, about the middle of last century, afforded not less than £40,000 or £50,000 worth of silver; but it was long since abandoned.

Mexico and Peru are at present the most productive in silver. In Mexico it has been obtained mostly from its ores, while it occurs principally native in Peru. During the first 18 years of the present century, more than 8,180,000 marks of silver were afforded by the mines of Guanaxuato alone. Of the 8,000,000 sterling which it is calculated is the value of silver annually afforded by the mines of the world, about two thirds are obtained from Mexico.

The uses of silver as a material for coins, also in the manufacture of plate and various articles of luxury, are well known. For coinage it is alloyed in this country with 10 per cent. of copper, by which it is rendered harder, and consequently more durable. It is less malleable than gold, it being impossible to hammer it into unbroken leaves thinner than the hundred and sixty thousandth part of an inch, which is more than one third thicker than gold leaf.

MERCURY. Hydrargyrum fluidum.

Fluid Mercury, *M.* Native Mercury, or Quicksilven. Gediegen Quecksilber. Mercure Natif, *H.* Hydrargyum. Argentum Vivum. Spuma argenti. Liquor Æternalis, *Pliny.* Mercurius *of the alchemists.*

466. *Primary form:* the regular octahedron. Occurs in small fluid globules scattered through its gangue.

G.=13·568. *Lustre* metallic. *Color* tin-white. Opaque.

It is entirely volatile before the blowpipe, it vaporizing at the temperature of 662°, F. It becomes a solid at 39°, F., and with a little care will then crystallize in octahedrons. It dissolves readily in nitric acid.

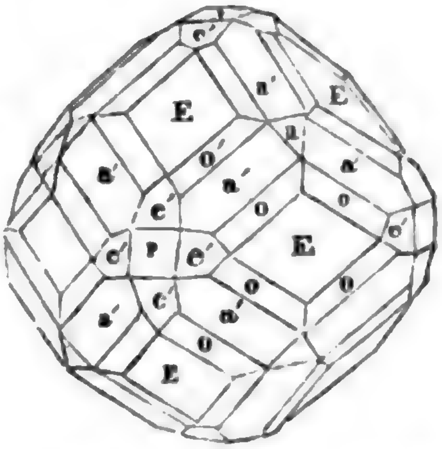
Obs. Fluid mercury is a rare mineral; the quicksilver of commerce is mostly obtained from cinnabar, one of its ores. Its most important mines are those of Idria, in Carniola, and Almaden, in Spain. At Idria it occurs interspersed through a kind of slate clay, from which it is obtained by washing. The Idria mines, at the present time, afford annually, from its ores and the native metal, about 164 tons, which is a less quantity than formerly. Native mercury is also found in small quantities at Wölfstein and Mörsfield, in the Palatinate, in Carinthia, Hungary, Peru, and other countries. It has been lately discovered at Peyrat le Chateau, in the department of the Haute Vienne, in a disintegrated granite, unaccompanied by cinnabar.

Mercury is of great importance in the extraction of gold and silver ores, for which purpose it is exported in large quantities to South America. It is also employed for silvering mirrors, for thermometers and barometers, for percussion powders, and for various other purposes connected with medicine and the arts.

The common name of this metal, quicksilver, is a translation of the old name, argentum vivum, and in part also of hydrargyrum, which signifies liquid silver.

AMALGAM. Hydrargyrum dodecahedrum.

Dodecahedral Mercury, *M.* Native Amalgam. Naturlich Amalgam, *W.* Amalgam, *Haus.* and *L.* Mercure Argentif, *H.*



467. *Primary form:* the rhombic dodecahedron. *Secondary forms:* figs. 4, 6, 8, 9, 16, Pl. I., also the annexed figure. *Cleavage* parallel to E, or the faces of the dodecahedron, in traces. Occurs also massive.

H.=2—3·5. G.=10·5—14; 13·755, Haidinger. *Lustre* metallic. *Streak* and *color* silver-white. Opaque. *Fracture* conchoidal, uneven. Brittle. Cutting it with a knife is attended with a grating noise.

It contains, according to Klaproth (Beitrage, i. 183) and Cordier, (Phil. Mag. xiv. 41,)

Mercury	64	72·5
Silver	36=100, K.	27·5=100, C.

The first of these analyses corresponds nearly to two atoms of mercury and one of silver; the second to three atoms of mercury and one of silver.

The blowpipe heat volatilizes the mercury, and leaves a globule of pure silver. When rubbed on copper it communicates to it a silvery lustre. It dissolves in nitric acid.

Obs. This rare species occurs principally in the Palatinate, at Moschellandsberg, where occasionally large and highly modified crystals are found. It is associated with mercury and cinnabar, in ferruginous and argillaceous veins, and is said to occur where the veins of mercury and silver intersect one another. It has also been found at Rosenau, in Hungary, and has been observed in the mine of Sala, in Sweden.

LEAD. Plumbum octahedrum.

Hexahedral Lead, ***Haid.*** **Gediegen Blei,** ***L.*** **Plomb Natif. Saturnus,** ***of the alchemists.*** **Plumbum nigrum.**

468. *Primary form:* the regular octahedron. In delicate membranes, and in small globular masses.

H.=1·5. G.=11·3523. *Lustre* metallic. *Color* lead-gray. Opaque. *Fracture* hackly. Malleable and ductile.

It fuses readily, and covers the supporting charcoal with a yellow oxyd.

Obs. This species has been found in small quantities in Michigan, on the Anglaise river, forming delicate membranes in the cleavage joints of galena. It is reported as occurring at Alston, in Cumberland, in minute globules imbedded in galena. It has also been observed in the lava of Madeira.

The uses of lead are too well known to require enumeration.

BISMUTH. Bismutum octahedrum.

Octahedral Bismuth, ***M.*** **Native Bismuth, Gediegen Wismuth,** ***W.*** **Bismuth Natif,** ***H.*** **Bisemutum,** ***Agricola.*** **Plumbum Cinereum. Tectum Argenti. Antimonium Femininum.**

469. *Primary form:* the regular octahedron. *Cleavage* highly perfect, parallel with the faces of the octahedron. Occurs also in reticulated and arborescent shapes, and foliated and granular masses.

H.=2—2·5. G.=9·737. *Lustre* metallic. *Streak* and *Color* silver-white, with a reddish hue; subject to tarnish. Opaque. *Fracture* not observable. Sectile. Brittle when cold, but when heated may be malleated.

It is pure bismuth, excepting occasionally a slight admixture of arsenic. It fuses readily, its fusing temperature being as low as 476° F. Before the blowpipe it evaporates, and leaves a yellow coating on the charcoal. It dissolves in nitric acid; subsequent dilution causes a white precipitate. Crystallizes readily from fusion.

Bismuth occurs in veins which traverse gneiss and clay slate, accompanying various ores of silver, cobalt, lead, and zinc. It occurs the most abundantly at the silver and cobalt mines of Saxony and Bohemia, Schneeberg, Annaberg, Altenberg, Joachimstahl, Johanngeorgenstadt, &c. It has also been found at Modum, in Norway, and Fahlun, in Sweden. At Schneeberg it forms arborescent delineations in brown jasper. At Wheal Sparnon, near Redruth, and at Carrock Fell, in Cumberland, it is associated with ores of cobalt; formerly it was met with near Alloa, in Stirlingshire.

Lane's Mine, in Monroe, Conn., is its only known locality in the United States;

it is there associated with wolfram, tungstate of lime, galena, blende, &c., and is imbedded in quartz.

Bismuth is employed in the formation of type metal, pewter, solder, &c. It is one of the constituents of the alloy, called, from its extreme fusibility, *fusible metal*, it melting at a temperature below that of boiling water; the proportions of the component parts of this alloy are 8 parts of Bismuth, 5 of Lead, and 3 of Tin. It is sometimes used for taking casts of delicate objects that would be destroyed by heat.

BISMUTH SILVER. BISMUTUM ARGENTICUM.

Bismuthic Silver Ore. Wismuth Silber, *of the Germans.* **Bismuth Sulfuré Plombo-Argentifère,** *Levy.*

470. Rarely presents acicular or capillary crystallizations; generally in amorphous masses.

Soft. *Lustre* metallic. *Color* tin-white or grayish; subject to tarnish. Opaque. *Fracture* uneven. Sectile.

It contains Bismuth 27, Lead 33, Silver 15, Iron 4·3, Copper 0·9, Sulphur 16·3. It is soluble in nitric acid. Before the blowpipe it fuses readily into a silver button, covering the charcoal with the oxyds of lead and bismuth.

OBS. It accompanies copper pyrites, in amorphous masses, at Schapbach, in the Valley of Kintzig, in Baded. It is worked as an ore of silver.

COPPER. CUPRUM OCTAHEDRUM.

Octahedral Copper, *M.* **and** *J.* **Gediegen Kupfer,** *of the Germans.* **Cuivre Natif,** *H.* **Venus** *Alchem.*

471. *Primary form:* the regular octahedron. *Secondary forms:* figs. 1—11 inclusive, Pl. I. *Cleavage* none. *Compound crystals:* composition parallel to a face of the octahedron; variously modified. *Imperfect crystallizations:* arborescent and filiform shapes; amorphous.

H.=2·5—3. G.=8·5844, Haüy. *Lustre* metallic. *Streak* metallic shining. *Color* copper-red. Ductile and malleable. *Fracture* hackly.

It consists purely of copper. Before the blowpipe it fuses readily; on cooling, it is covered with a coating of black oxyd. It dissolves readily in nitric acid, with the extrication of the red fumes of nitrous acid, and produces a blue solution with ammonia.

OBS. Copper occurs in beds and veins accompanying its various ores, and sometimes associated with iron. It is frequently found in loose masses imbedded in the soil.

The finest crystalline specimens are brought from Siberia and the island of Nalsoe, in Faroe, where it is associated with fibrous mesotype in amygdaloid, and though mostly disseminated in minute particles, it sometimes branches through the rock with extreme beauty. Cornwall, and many of the mines near Redruth, however, are the greatest repositories of this metal; it also occurs in considerable quantities at the Consolidated Mines, Wheal Buller, and others. Its crystallizations are seldom regular, but usually lengthened, and grouped in elongated series, similar to native silver. Brazil also affords native copper.

This metal has been found native throughout the red sandstone region of the United States, particularly in Massachusetts, Connecticut, and still more abundantly in New Jersey, where it has been met with at several different places, sometimes in fine crystalline masses. A magnificent mass exists near Lake Superior. In the Yale College cabinet there is a large irregular mass weighing 137 lbs. from the vicinity of this Lake, near the On-ta-naw-gaw river. Another specimen still remains on the west bank of this river, which, according to the computation of Mr. Henry R. Schoolcraft, who has seen and described it, weighed, in 1821, about 2200 lbs. Smaller masses are quite common in the same region.*

Copper is of very extensive application in the arts. In the pure state it forms various utensils, the sheathing of ships, &c. Alloyed with zinc, it constitutes brass, and with tin, it forms bell metal. A similar alloy, in different proportions, composed the material of which the ancients made their *brass* weapons and cutting instruments. The proportion in these instruments was about as five of copper to one of tin, which is the ratio that affords an alloy of maximum hardness. This was the constitution of an ancient dagger, analyzed by Hielm. The term χαλκος, or *æs*, which was applied to this material, was also a general appellation for copper, and the various alloys in which it was the principal ingredient.

TELLURIUM. Tellurium hexagonum.

Native Tellurium, *M.* and *P.* Hexahedral Tellurium, *P.* Gediegen Sylvan, *W.* Gediegen Tellur, *Haus.* and *L.* Tellure Natif Auro-Ferrifère, *H.*

472. It has been found in crystals, which, according to Mr. W. Phillips, are regular six sided prisms, with the terminal edges replaced; P : e=122° 24′. *Cleavage* undetermined. It also occurs massive and granular.

H.=2—2·5. G.=5·7—6·1, Phillips. *Lustre* metallic. *Streak* and *Color* tin-white. Brittle.

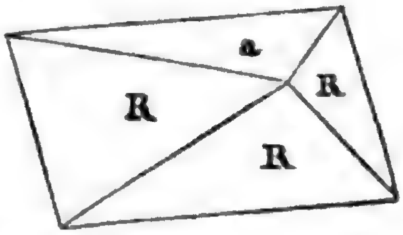
It contains, according to Klaproth, Tellurium 92·55, Iron 7, and Gold 0·25. It fuses readily on charcoal, burning with a greenish flame, and volatizes almost entirely in white vapors.

Obs. Native tellurium has hitherto been found only in the mine of Maria Loretto, at Facebay, near Zalathna, in Transylvania, where it occurs in sandstone, accompanying quartz, iron pyrites, and gold. About forty years since it was found in considerable abundance, and was melted to extract the small quantity of gold it contains. At present it is very rare.

NATIVE ANTIMONY. Stibium rhombohedrum.

Rhombohedral Antimony, *M.* Dodecahedral Antimony, *J.* Native Antimony, Gediegen Antimon, Oder Speisglas, *W.* Gediegen Speisglanz, *Haus.* Antimoine Natif, *H.*

473. *Primary form:* an obtuse rhombohedron; R : R=117° 15′. *Secondary form:* the annexed figure. *Cleavage* highly perfect and producing a surface of splendent lustre, parallel to a, also distinct, parallel with R. Seldom in crystals: generally massive, structure lamellar.



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* Silliman's Am. Jour. III. 201, on the Native Copper of the southern shore of Lake Superior, by H. R. Schoolcraft.

H.=3—3·5. G.=6·72, Klaproth; 6·646, a Swedish variety. *Lustre* metallic. *Streak* and *color* tin-white. Rather brittle; not ductile.

It contains, according to Klaproth, Antimony 98, Silver 1, and Iron 0·25=99·25. Before the blowpipe it soon melts into a globule, which continues to burn though the heat be removed; a continuation of the heat causes it to evaporate in white fumes, which are deposited around the globule. Under the microscope, yellowish white octahedrons, probably of antimonious acid, are seen to be first formed, and subsequently, prismatic crystals of oxyd of antimony, with which at last the whole globule is covered. It crystallizes readily from fusion.

Obs. It occurs in lamellar concretions in limestone at Sahlberg, near Sahla, in Sweden; at Andreasberg, in the Hartz; in argentiferous veins in gneiss, at Allemont, in Dauphiny; at Przibram, in Bohemia; in Mexico, and other places. It is often accompanied by the following species, from which, however, it is readily distinguished by means of the blowpipe. Antimony is variously employed in the arts, and for pharmaceutical preparations. One part of antimony is alloyed with 16 parts of lead in the formation of type metal. With tin, it forms the metal on which music is engraved.

ANTIMONIAL SILVER. Stibium rhombicum.

Prismatic Antimony, *M.* Octahedral Antimony, *J.* Antimoniet of Silver, Spiesglas-Silber, *W.* Silber Speissglanz, *Haus.* Antimon Silber, *L.* Argent Antimonial, *H.*

474. *Primary form:* a right rhombic prism. *Cleavage* parallel to P distinct. *Compound crystals:* similar to those of Arragonite and white lead ore. *Imperfect crystallizations:* composition granular, particles of various sizes, weakly coherent.

H.=3·5—4. G.=9·44—9·8; 9·4406, Haüy. *Lustre* metallic. *Streak* and *Color* silver-white, inclining to tin-white. Opaque. *Fracture* uneven.

It contains, according to Klaproth, (Beitrage, ii. 298,) and Vauquelin, (Haüy, iii. 392,)

Silver	84	76	77	78
Antimony	26=110, K.	24=100, K.	23=100, K,	22=100, V.

Before the blowpipe gray fumes of antimony are given off, and a gray metallic globule, which is not malleable, is left. By continuing the heat the silver is obtained.

Obs. It occurs in veins at Altwolfach, in Furstenberg, Wittichen, in Swabia, and Andreasberg, in the Hartz, associated with several ores of silver, native arsenic, galena, and other species.

If found in sufficient quantity, this would be a valuable ore of silver; but it is yet a rare mineral.

NATIVE ARSENIC. Arsenium rhombohedrum.

Native Arsenic, *M.* Gediegen Arsenik, *W.* Arsenic Natif, *H.* Arsenicum. Αῤῥενικον, Αρσενικον.

475. *Primary form:* an obtuse rhombohedron; $R:R=114^\circ\ 26'$. *Cleavage* imperfect parallel with a. Presents also reticulated, reniform, and stalactitic shapes; structure columnar or granular: when the former, a cleavage is observed perpendicular to the axis of the individual.

H.=3·5. G.=5·672, Harepath. It varies from 5·67—5·93. *Lustre* metallic. *Streak* and *Color* tin-white, tarnishing soon to dark-gray.

When heated it volatilizes in a white smoke, which has the odor of garlic; if heated nearly to redness it burns with a pale bluish flame, giving out alliaceous white fumes.

Obs. Native arsenic commonly occurs in veins in primitive mountains, and is often accompanied by red silver ore, realgar, blende, and other metallic minerals. The silver mines of Freiberg, Annaberg, and Schneeberg, afford this metal in considerable quantities. It occurs also at Joachimstahl, in Bohemia; at Andreasberg, in the Hartz; at Kapnik, in Transylvania; at Orawitza, in the Bannat; at Zincoff, in Siberia, in large masses, and at St. Marie aux Mines, in Alsace.

Its peculiar odor when heated, which is also apparent when struck with a hammer, is quite characteristic. Arsenic is a virulent poison. It is employed in several pharmaceutical preparations. It is also used in giving a peculiar tint to glass, and in various metallurgical operations.

The name Arsenic, is derived from the Greek, αρσενικον, or αρρενικον, *masculine*, a term applied to orpiment or sulphuret of arsenic, on account of its potent properties.

ORDER IX.—PYRITINEA.

ARSENICAL SILVER. ARGYRITES ARGENTEUS.

Arsenical Antimonial Silver, *P.* Arseniet of Silver, *Thom.* Arsenik-Silber, *W.* Argent Arsenical, *Levy.* Argent Antimonial Ferro-Arsenifère, *H.*

476. *Primary form:* unknown; occurs generally mammillated, or in curved lamellar distinct concretions, consisting of very thin crystalline coats.

H.=4. G.=9·4. *Lustre* shining or glimmering, metallic. *Streak* shining. *Color* nearly that of native silver, but usually tarnished of a blackish color. Opaque. *Fracture* uneven. Sectile.

According to Klaproth, (Beitrage, i. 187,) the variety from Andreasberg contains, Silver 12·75, Arsenic 35, Antimony 4, and Iron 44·25.

Before the blowpipe it affords a strong alliaceous odor, accompanying the fumes of the volatilized arsenic and antimony; and their remains a globule of impure silver surrounded by a slag.

OBS. It occurs at Andreasberg, in the Hartz; at Guadalcanal, in Estremadura, in Spain; and at Kongsberg, in Norway, associated with antimonial silver, galena, and native arsenic. The arsenical fumes under the blowpipe, and its liability to tarnish, distinguish it from the antimonial silver, for which it might be mistaken.

NICKEL STIBINE. ARGYRITES EUTOMUS.

Eutomous Cobalt Pyrites, *M.* Nickeliferous Gray Antimony, Nickelspiesglaserz, *of the Germans.* Antimoine Sulfuré Nickelifère, *H.*

477. *Primary form:* the cube. *Cleavage* parallel with P perfect. Occurs also massive—structure granular.

H.=5—5·5. G.=6·451, a cleavable variety. *Lustre* metallic. *Color* steel-gray, inclining to silver-white. Brittle.

Its composition, as determined by Klaproth and Stromeyer, is as follows:

Nickel	36·60	25·25
Antimony	43·80	47·75
Sulphur	17·71	15·25
Arsenic	——	11·75
Iron and Manganese	1·89=100, S.	——=100, K.

In the blowpipe flame it is partly volatilized, and the charcoal is covered with a white coating. Ultimately it fuses into a metallic globule, which communicates a blue color to glass of borax.

OBS. It occurs in the duchy of Nassau, in the mines near Freussberg, associated with sparry iron, galena, and copper pyrites.

ANTIMONIAL NICKEL. ARGYRITES HEXAGONUS.

Antimoniet of Nickel.

478. *Primary form:* a hexagonal prism. *Secondary form:* thin hexagonal plates.

H. = about 5·5. *Lustre* metallic, splendent. *Streak* reddish-brown. *Color* in the fresh fracture light copper-red, inclining strongly to violet. Opaque. *Fracture* uneven—small subconchoidal. Brittle. Not acted on by the magnet.

According to Stromeyer, (Poggendorf's Annalen, xxxi. 134,) it contains, Nickel 28·946, Antimony 63·734, Iron 0·866, Sulphuret of Lead 6·437=99·983. Some antimony sublimes before the blowpipe.

OBS. It occurs in the Andreasberg mountains, associated with calcareous spar, galena, and smaltine.

COPPER NICKEL. ARGYRITES CUPRICOLOR.

Prismatic Nickel Pyrites, *M.* Arseniet of Nickel, *Thom.* Kupfer Nickel, *W.* Arsenik-Nickel, *L.* Nickel Arsenical, *H.*

479. *Primary form* is stated to be trimetric. Occurs usually massive—structure nearly impalpable; also reniform, with a columnar structure.

H.=5—5·5. G.=7·655. *Lustre* metallic. *Streak* pale brownish-black. *Color* copper-red. Opaque. *Fracture* uneven. Brittle.

It contains, according to Pfaff, (Schweig. Journ. xxii. 256,) Berthier, (Ann. des Mines, iv. 467,) and Stromeyer, (Mohs, ii. 447,)

Nickel	48·90	39·94	44·206
Arsenic	46·42	48·80	54·726
Iron	0·34	trace	0·337
Sulphur	0·80	2·00	0·401
Antimony	—	8·00	—
Lead	0·56=97·02, P.	Cobalt 0·16=98·9, B.	Lead 0·320=99·99, S.

According to Stromeyer's analysis, it is composed of one atom of arsenic and one of nickel. Before the blowpipe, on charcoal, it emits arsenical fumes and fuses into a white globule, which darkens by exposure to the air. In nitric acid it soon assumes a green coating, and in nitromuriatic acid is dissolved.

OBS. Copper nickel accompanies cobalt, silver, and copper, in the Saxon mines of Annaberg, Schneeberg, &c.; also in Thuringia, Hessia, and Styria, and at Allemont, in Dauphiny. It is occasionally observed in Cornwall.

It is found at Chatham, Conn., in gneiss, associated with smaltine.

Nickel is employed in the manufacture of what is called "German silver," of which it constitutes 17·48 per cent.; the other constituents are copper 53·9, and zinc 29·13.

WHITE NICKEL. ARGYRITES HOFFMANNI.

Binarseniet of Nickel, *Thom.*

480. *Primary form:* supposed to be the cube. *Secondary forms:* figs. 2 and 5, Pl. I. Occurs also massive.

Lustre metallic. *Color* tin-white. Opaque. *Fracture* uneven.

It contains, according to Booth, (Silliman's Am. Journ. xxix. 241,) and Hoffmann, (Poggendorf's Annalen, xxv. 491,)

	Riechelsdorf.		Schneeberg.
Arsenic	72.64		71·30
Nickel	20·74		28·14
Cobalt	3·37	Bismuth	2·19
Iron	3·25	Copper	0·50
Sulphur	— =100, B.		0·14=102·27, H.

It evolves arsenical fumes before the blowpipe, and fuses into a brittle metallic button. Fused with salt of phosphorus, it affords a clove-brown transparent glass in the outer, and a brown opaque glass in the inner flame, thus indicating the presence of nickel.

Obs. It occurs in crystals in the cobalt mine of Riechelsdorf, in Hesse; also massive at Schneeberg, mixed with quartz, and often covered with a thin coating of nickel green.

NICKEL GLANCE. Argyrites decrepitans.

Sulpho-arsenide of Nickel, *Thom.*

481. *Primary form:* the cube. *Cleavage* highly perfect parallel with the primary form. Occurs also in lamellar and granular masses.

H.=5·5. G.=6·097—6·129. *Lustre* metallic. *Color* silver-white—steel gray.

It contains, according to Berzelius, (Kong. Vet. Acad. Handl., 1820, p. 241,)

Arsenic	55·50	53·32	48·06
Nickel	28·17	27·00	19·29
Sulphur	12·67	14·40	30·80
Iron	3·63	5·29	2·99
Silica	0·61=100·58.	— =100·01.	1·00=102·14.

When heated it decrepitates with great violence. Ignited in a glass tube, sulphuret of arsenic sublimes as a transparent yellowish-brown mass, which remains clear on cooling.

Obs. It occurs at Loos, in Helsingland, Sweden, and in the Albertine mine, near Harzgerode, in the Hartz. It is associated with copper pyrites, galena, calcareous spar, fluor spar, and quartz. It was noticed by Cronstedt, but first analyzed and described by Pfaff.

LEUCOPYRITE. Argyrites acrotomus.

Axotomous Arsenical Pyrites, *M.* Prismatic Arsenical Pyrites, *J.*

482. *Primary form:* a right rhombic prism; M : M=122° 26′. *Secondary form:* similar to the figure of liroconite, p. 241; a : a (adjacent planes) =51° 20′. Occurs also massive.

H.=5—5·5. G.=7·228, specimen from Silesia; 7·337, a crystal from Bedford Co., Penn. *Lustre* metallic. *Streak* grayish-black. *Color* between silver-black and steel-gray. *Fracture* uneven. Brittle.

Obs. It occurs associated with copper nickel at Schladming, in Styria; with serpentine at Richenstein, in Silesia; and at Löling, near Hüttenberg, in Carinthia, in a bed of sparry iron, associated with bismuth and scorodite.

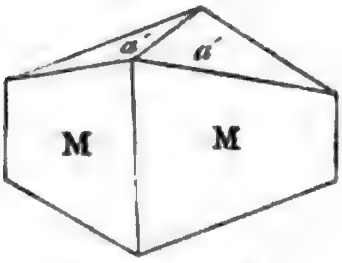
A crystal, weighing two or three ounces, has been found in Bedford Co., Penn., but it is not known under what circumstances. In Randolph Co., N. C., a mass was found weighing nearly two pounds.

MISPICKEL. ARGYRITES PERITOMUS.

Prismatic Arsenical Pyrites, *M.* Marcasite. Sulpho-arsenite of Iron. Arsenik-kies, *of the Germans.* Fer Arsenical, *H.*

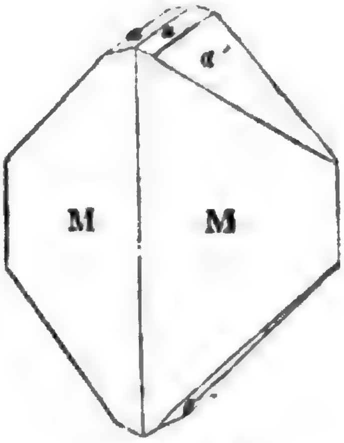
483. *Primary form:* a right rhombic prism; M : M=111° 53′. *Secondary forms:*

1.



Franconia, N. H.

2.



Franconia, N. H.

$a' : a'$=145° 26′, $a : a$=118° 32′, $a'' : a''$=80° 8′. *Cleavage* parallel to M rather distinct. *Compound crystals:* composition of the first kind parallel with M. *Imperfect crystallizations:* structure columnar—straight and divergent, or irregular; fine granular, or impalpable—particles strongly coherent.

H.=5·5—6. G.=6·127. *Lustre* metallic. *Streak* dark grayish-black. *Color* silver-white, inclining to steel-gray. *Fracture* uneven. Brittle.

It contains, according to Stromeyer and Chevreul,

Iron	36·04	34·94
Arsenic	42·88	43·42
Sulphur	21·08=100, S.	20·13=98·49, C.

On charcoal, before the blowpipe, copious arsenical fumes are driven off, and a globule is obtained of nearly pure sulphuret of iron, which acts on the needle like magnetic pyrites. It gives fire with steel, emitting at the same time an alliaceous odor. It dissolves in nitric acid, with the exception of a whitish residue.

The localities of mispickel are principally in primitive regions, and its usual mineral associates are silver, lead, and tin, iron and copper pyrites, and blende. It is abundant at Freiberg and Munzig, where it occurs in veins; and also in beds at Breitenbrun and Raschau, Andreasberg, Joachimstahl, Tunaberg in Sweden; Wheal Mawdlin, and Unanimity, in Cornwall, are other localities.

It is met with in fine crystallizations in gneiss at Franconia, N. H., associated with copper pyrites. A massive variety occurs at Worcester, Mass., and at Chatham, Conn., associated with smaltine and copper nickel; and at Monroe, Conn., accompanying wolfram, magnetic pyrites, and native bismuth.

SMALTINE. ARGYRITES OCTAHEDRUS.

Octahedral Cobalt Pyrites, *M.* Gray Cobalt. Tin-White Cobalt, *J.* Binarseniet of Cobalt, *Thom.* Weisser-Speiskobold, *W.* Speiskobalt, *Haus.* and *L.* Cobalt Arsenical, *H.*

484. *Primary form:* the regular octahedron. *Secondary forms:* figs. 1—10, and fig. 16, Pl. I.; also several of these forms in combination. *Cleavage* most distinct parallel to the primary faces; also in traces parallel to the faces of the cube and rhombic dodecahedron. *Imperfect crystallizations:* reticulated, and other imitative shapes; granularly massive—particles of various sizes.

H.=5·5. G.=6·466. *Lustre* metallic. *Streak* grayish-black. *Color* tin-white, inclining, when massive, to steel-gray. Opaque. *Fracture* granular and uneven. Brittle.

The following is its constitution, according to the analysis of Stromeyer, (Ann. Phil. x. 228,) Arsenic 74·2174, Cobalt 20·3135, Iron 3·4257, Copper 0·1586, Sulphur 0·8860=99·0012.

Heated in a candle it emits copious arsenical fumes, and melts into a white brittle metallic globule. It colors borax and other fluxes blue, and produces with nitric acid a pink solution.

OBS. Smaltine usually occurs in veins, accompanying other ores of cobalt and ores of silver and copper; also, in some instances, with copper nickel and mispickel.

With silver and copper it occurs at Freiberg, Annaberg, and particularly Schneeberg, in Saxony; at Joachimstahl, in Bohemia, the reticulated varieties are frequently found imbedded in calc spar; also at Wheal Sparnon, in Cornwall; at Riechelsdorf, in Hessia, in veins of cupriferous shale.

Chatham, Conn., is the only known locality of this mineral in the United States. It there occurs in veins traversing gneiss, associated with mispickel and copper nickel. Deep shafts have been cut into the rock at this place for the purpose of working the ore, but the project is now given up.

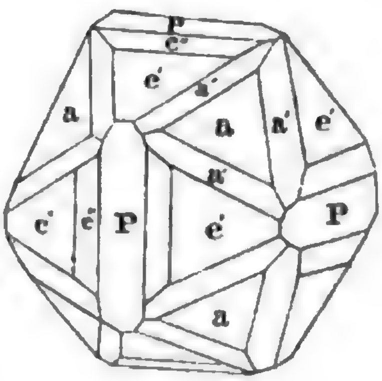
The presence of copper nickel, which is a very common associate with this species, is the cause of no small annoyance to the miner; for even a minute quantity suffices to destroy the fine blue color obtained from cobalt. The ore, when separated from this attendant, is roasted to drive off the arsenic, and finely pulverized, and is then prepared for giving the blue color employed in painting porcelain and stoneware. With silex and potash it affords smalt.

The *radiated white cobalt* of Werner, from Schneeberg, contains, according to John, Arsenic 65·75, Cobalt 28·00, Iron with Manganese 6·25=100.

COBALTINE. ARGYRITES HEMI-CUBICUS.

Hexahedral Cobalt Pyrites, *M.* Silver White Cobalt. Bright White Cobalt. Glance Cobalt. Sulpho-Arseniet of Cobalt, *Thom.* Glanz Kobold, *W.* Kobalt Glanz, *Haus* and *L.* Cobalt Gris, *H.*

485. *Primary form:* the cube. *Secondary forms:* figs. 42—47 inclusive, Pl. I., also the annexed fig. P : e″=166° 30′, P : e′=153° 26′ 5½″. *Cleavage* parallel with P, perfect. Planes P, longitudinally striated. Occurs also massive; structure granular—particles small, but discernible.



H.=5·5. G.=6·298. *Lustre* metallic. *Streak* grayish-black. *Color* silver-white, inclining to red. *Fracture* uneven and lamellar. Brittle.

Google

It contains, according to Fassaert, Klaproth, and Stromeyer,

Cobalt	36·66	44·0	33·1012
Arsenic	49·00	55·5	43·4644
Sulphur	6·50	0·5	20·0840
Iron	5·66=97·82, T.	—=100, K.	2·2324=99·8820, S.

The blowpipe heat causes the extrication of arsenic in white fumes, and produces, after roasting, a dull black metallic globule, which attracts the magnet. It colors borax blue, and effervesces in heated nitric acid, like the preceding species.

Obs. It occurs at Tunaberg and Hokensbo, in Sweden, in large, splendid, well defined crystals; also at Modum, in Norway, where it is mined. Other localities are at Querbach, in Silesia, and at Botallick, near St. Just, and in other places in Cornwall. The most productive mines are those of Welna, in Sweden, where it occurs in mica slate. These mines were first opened in 1809.

This, and the preceding species, afford the greatest part of the smalt of commerce. It is also employed in porcelain painting.

TERARSENID OF COBALT. Argyrites Karsteni.

Bismuth Cobalt Ore. Terarseniet of Cobalt.

486. Structure radiated.

G.=6—6·7, of pure specimens; usually from an admixture of grains of quartz, as low as 4·5 or 4·7. *Lustre* metallic; sometimes splendent. *Streak* dull; same as color. *Color* between lead-gray and steel-gray.

It contains, according to Karsten, Arsenic 77·9602, Cobalt 9·8866, Iron 4·7695, Bismuth 3·8866, Copper 1·3030, Nickel 1·1063, Sulphur 1·0160=99·9282. Before the blowpipe it gives out fumes of arsenous acid, and coats the charcoal with a yellow crust, the assay becoming at the same time brown. When well roasted, it colors glass of borax blue.

Obs. It has been observed only at Schneeberg, in Saxony.

COBALTIC PYRITES. Argyrites cubicus.

Isometric Cobalt Pyrites, *M.* Sulphuret of Cobalt, *Thom.* Cobalt Kies, *J.* Kobaltkies.

487. *Primary form:* the cube. *Secondary forms:* figs. 2, 3, and others, Pl. I. *Cleavage* parallel to the faces of the cube imperfect. Occurs also massive—structure granular, sometimes impalpable.

H.=5·5. G.=6·3—6·4. *Lustre* metallic. *Color* pale steel-gray, inclining to copper-red when tarnished. Opaque. *Fracture* uneven or subconchoidal.

The Swedish variety contains, according to Hisinger, (Afhandlingar iii. 316,) Cobalt 43·2, Copper 14·4, Sulphur 38·5, Iron 3·53=99·63. It gives off a sulphurous odor when heated, and after roasting, colors glass of borax blue.

Obs. It occurs in gneiss, at Bastnaes, near Riddarhyttan, in Sweden, associated with copper pyrites and hornblende; and at Mussen, near Siegen, in Prussia, with heavy spar and carbonate of iron.

ARSENID OF MANGANESE. ARGYRITES MANGANICUS.

Arseniet of Manganese, *Thom.* Arseniuret of Manganese.

488. Occurs in botryoidal masses, also amorphous ; structure foliated or granular.

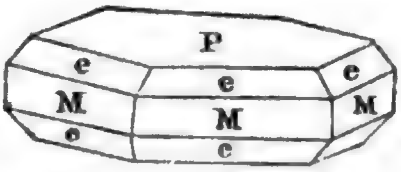
H. above 5 ? stated as hard. G.=5·55. *Lustre* metallic. *Color* grayish-white. Opaque. *Fracture* uneven.

According to the analysis of Mr. Kane, (Quarterly Journal of Science, new series, vi. 381,) it contains Manganese 45·5, Arsenic 51·8, and a trace of Iron=97·3. Before the blowpipe it burns with a blue flame, and falls into powder; at a higher temperature the arsenic evaporates, and covers the charcoal with a white powder. It dissolves in aqua regia, without leaving any residue.

OBS. It is found in Saxony, and was first observed by Mr. R. J. Kane, of Dublin, attached to a mass of galena from that country.

MAGNETIC PYRITES. PYRITES HEXAGONUS.

Rhombohedral Iron Pyrites, *M.* Sulphuret of Iron. Magnetkies, *W.* Leberkies, *L.* Fer Sulfuré Ferrifère, Fer Sulfuré Magnetique *H.*



489. *Primary form:* a hexagonal prism. *Secondary form:* similar to fig. 125, Pl. II.; also the annexed figure. P : e=108° 41′, M : e=161° 19′, M : e=150°. *Cleavage* perfect parallel with P; less so in the direction of M. Commonly massive and amorphous; structure granular.

H.=3·5—4·5. G.=4·631, a crystalline variety. *Lustre* metallic. *Streak* dark grayish-black. *Color* between bronze-yellow and copper-red. *Fracture* small subconchoidal. Brittle. Slightly attractable by the magnet, and subject to speedy tarnish.

It contains, according to Hatchett, (Phil. Trans. 1804, p. 315,) and Stromeyer, (Gilbert's Annalen, xlviii. 183,)

	Cornwall.	Utön.	Pyrenees.
Iron	63·5	59·85	56·37
Sulphur	36·5=100, H.	40·15=100, Strom.	43·63=100, Strom.

Before the blowpipe it affords fumes of sulphurous acid and the odor of sulphur. On charcoal, in the exterior flame, it is converted into a globule of red oxyd of Iron; in the interior flame it fuses and continues to glow, after the blowpipe is removed. The black mass, which on cooling is obtained, exhibits a crystalline structure on a surface of fracture, a metallic lustre, and a yellowish color. It dissolves in dilute sulphuric acid.

OBS. Crystalline plates of this species have been observed at Kongsberg, in Norway, and at Andreasberg, in the Hartz; but they are of rare occurrence. It generally occurs massive, in fissures of primitive rocks. Cleavable varieties accompany iolite at Bodenmais, in Bohemia. The compact specimens are abundant in Cornwall, at Appin in Argyleshire, in Saxony, Silesia, and the Hartz. It has also been observed in the lavas of Vesuvius, and in some meteoric stones.

Trumbull, Conn., and the adjoining town of Monroe, afford the cleavable variety of this species; at the former place, it occurs in the topaz and fluor vein; at the latter, in a quartz vein, in gneiss. Compact varieties occur with iron pyrites, at Stafford and Shrewsbury, Vt., and in many parts of Massachusetts.

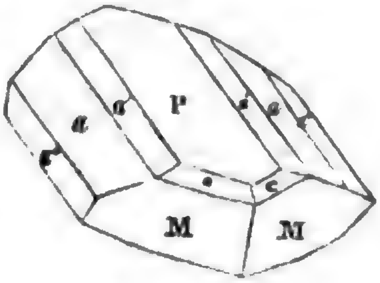
It is mined for its sulphur, and for the fabrication of sulphuric acid and sulphate of iron.

Its inferior hardness is sufficient to distinguish it from the following species.

WHITE IRON PYRITES. Pyrites rhombicus.

Prismatic Iron Pyrites, *M.* and *J.* White Iron Pyrites. White Bisulphuret of Iron. Radiated Pyrites. Spear Pyrites. Hepatic Pyrites. Cellular Pyrites. Kamkies, Leberkies, Zeikies, Sparkies, Wasserkies, *of the Germans.* Fer Sulphuré Aciculaire Radié, Fer Sulfuré Blanc, *H.*

1.



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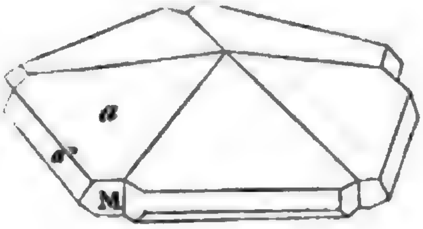


490. *Primary form:* a right rhombic prism; M : M=106° 36′. *Secondary form:* fig. 1., of a crystal from Cornwall. Similar crystals, with merely the modifying planes *a*, have been observed at Warwick, N. Y. P : *a*=130° 55′. *Cleavage* parallel with M, rather perfect. Planes *a* and *a″* longitudinally striated. *Compound crystals:* composition of the first kind—parallel with M. Compound crystals of five individuals, united by the acute lateral angle, are of frequent occurrence. This angle is about one fifth of 360°, which accounts for the occurrence of these forms. For remarks on the structure of other analogous forms, see § 76. Other compound crystals occur, whose structure depends on composition of the third kind, or parallel to *a*. *Imperfect crystallizations:* globular, reniform, and other imitative shapes—structure straight columnar—impalpable; massive; structure columnar or granular. *Pseudomorphs* in low nearly regular hexagonal prisms.

H.=6—6·5. G.=4·678—4·847. *Lustre* metallic. *Streak* grayish-black or brownish-black. *Color* pale bronze-yellow, sometimes inclining to green or gray. *Fracture* uneven. Brittle.

It contains, according to Hatchett, (Phil. Trans. 1804, p. 325,) and Berzelius, (Mineralogie, p. 263,)

Iron	46·4	45·66	45·07
Sulphur	53·6	54·34	53·35
Manganese	—	—	0·70
Silica	—=100, H.	—=100, B.	0·80=99·92, B.

Before the blowpipe, on charcoal, it becomes red, the sulphur is mostly volatilized, and an oxyd of iron remains. Some of the varieties are very liable to decomposition.

Obs. This species was formerly subdivided according to the different forms the mineral presents. *Radiated pyrites* included the radiated masses and more simple crystals; *spear pyrites*, the macled crystals; *hepatic pyrites*, or *leberkies*, (so called from *ἧπαρ*, *liver*,) the decomposed liver-brown tessular crystals which were original iron pyrites, and also certain hexagonal pseudomorphs; *cockscomb pyrites*, or *kamkies*, the crest-like aggregations of this species of pyrites; *cellular pyrites*, the cellular varieties, formed by the decomposition of crystals of galena, which contained films of pyrites between its layers, thus producing a honeycomb appearance.

The spear pyrites occurs abundantly in the plastic clay of the brown coal formation, at Littmitz and Altsattell, near Carlsbad, in Bohemia, and is extensively mined for its sulphur and the formation of sulphate of iron. The radiated variety occurs at the same places; also at Joachimstahl, and in several parts of Saxony. The cockscomb variety occurs with galena and fluor spar, in Derbyshire. It occurs in stalactitic concretions, in Cornwall.

At Warwick, N. Y., is the only known locality of crystallized specimens in the United States. It is there imbedded in granite, in single crystals, and is associated with zircon. Massive fibrous varieties, abound throughout the mica slate of New England, and particularly at Cummington, Mass., where it is associated with Cummingtonite and garnet. It occurs also at Lane's mine, in Monroe, Conn., and in the topaz and fluor vein, in Trumbull, Conn.; also in gneiss, at East Haddam.

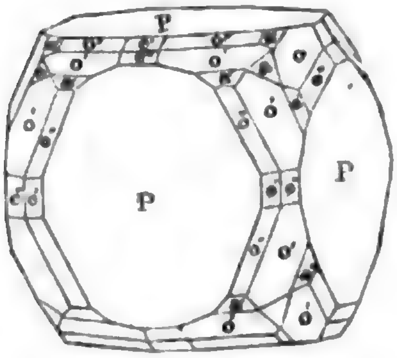
Cockscomb pyrites is employed in the manufacture of sulphur, sulphuric acid, and sulphate of iron, though less frequently than the common iron pyrites. Its color is considerably paler than the ordinary pyrites, and also it is more liable to decomposition.

IRON PYRITES. Pyrites cubicus.

Hexahedral Iron Pyrites, *M.* and *J.* Cubic Pyrites. Mundic. Marchasite. Bisulphuret of Iron, *Thom.* Gemeiner Schwefelkiés, Zelkies, *W.* Eisenkies, *L.* Fer Sulfuré, *H.* πυρίτης.

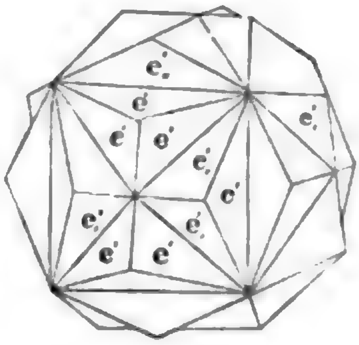
491. *Primary form:* the cube. *Secondary forms:* figs. 2, 3, 4, 14, 15, 16, 42, 43, 44, 45, 46, 47, 48, Pl. I.; also the annexed figures.

1.



Peru.

2.



Schoharie.

P : a=125° 15′ 51¾″, P : a′=144° 44′ 8¼″, P : e″=146° 18′ 36″, P : e′=153° 26′ 6″, P : o′=143° 18′ 3″, P : o″=150° 47′ 39″. *Cleavage* parallel to the faces of the cube and octahedron, more or less distinct. Planes P and e′ often striated. *Compound crystals:* Composition of *the second kind*, parallel to e′. This composition sometimes takes place parallel to each of the edges, when the form in fig. 2 is produced. *Imperfect crystallizations:* imbedded and implanted globules—surface crystalline—structure indistinctly columnar; massive, structure granular—particles strongly coherent.

H.=6—6·5. G.=4·83—5·031. *Lustre* metallic, splendent—glistening. *Streak* brownish-black. *Color* a characteristic bronze-yellow, nearly uniform. Opaque. *Fracture* conchoidal, uneven. Brittle. Strikes fire with steel.

It consists, according to Berzelius, of Iron 45·74, Sulphur 54·26, and is, therefore, a bisulphuret of iron. It becomes red in the oxydating flame of the blowpipe, and gives off fumes of sulphur; ultimately, there is obtained a globule of oxyd of iron, which is attractable by the magnet. It is soluble in nitric acid, except a white residue. Some varieties are very liable to decomposition on exposure to the atmosphere.

Obs. Iron pyrites occurs abundantly in rocks of all ages, from the oldest primitive to the most recent alluvial deposits. It usually occurs in small cubes, but often modified as above described; also in irregular spheroidal nodules and in veins, in clay slate, graywacke slate, the coal formation, &c. Cubes of gigantic dimensions have been found in some of the Cornish mines; pentagonal dodecahedrons and other forms occur on the island of Elba, sometimes three or four inches in diameter. Large octahedral crystals are found at Perzberg, in Sweden. Magnificent crystals have been brought from Peru; but still more brilliant and well finished crystals occur at Traversella, in Piedmont. Alston Moor, Derbyshire, Cornwall, Fahlun in Sweden, Kongsberg in Norway, are well known localities. The clay at Munden, near Hanover, and the chalk at Lewes, in Surry, have afforded some remarkable compound crystals. It has also been met with in the Vesuvian lavas, in small irregular crystals.

The United States have not hitherto afforded any very splendid specimens of this species. It is, however, very abundant. The limestone of Shoreham, Vt., and Schoharie, N. Y., have afforded some interesting forms. Highly polished crystals, similar to fig. 48, with the addition of plane e′, occur at Rossie, N. Y. Small octahedral crystals are common at Lane's mine, Monroe, Conn. It occurs thickly disseminated in graywacke, (mill stone grit,) in grains and small crystals near Utica, N. Y.

This species is of the highest importance in the arts, it affording the greater part of the sulphate of iron and sulphuric acid of commerce, and also a considerable portion of the sulphur and alum. The sulphur and sulphate of iron, or green vitriol, are commonly obtained at one and the same process. The pyrites is usually heated in clay retorts, by which about 17 per cent of sulphur is distilled over and collected. The ore is then thrown out into heaps and exposed to the atmosphere, and afterwards lixiviated. The green vitriol is thus dissolved, and thence is collected in ditches constructed for the purpose and crystallized. In other instances the ore is piled in heaps, after being broken in small pieces and then moistened, when decomposition goes on as before. This decomposition often takes place in cabinets, from merely the moisture of the atmosphere; but usually only in massive varieties. In Germany, the lixiviated liquid is employed for the production of sulphuric acid, by evaporating and distilling it; and the residue, which is an oxyd of iron, often called colcothar, is used as a coarse red pigment.

This species is also of importance in the smelting of ores, particularly those of silver.

Pyrites sometimes contains, mechanically mingled, a minute quantity (perhaps one five thousandth part) of gold, and is then termed auriferous pyrites. It occurs abundantly in the gold mines of Beresoff, in Siberia, and in Brazil, in detached disintegrating crystals of a dark-brown color.

The name *pyrites*, is derived from the Greek, πυρίτης, a term applied to this mineral, because, as Pliny states, "there was much fire in it," as was made apparent by friction. This term was applied also to flint and some siliceous millstones, on account of their external resemblance, to copper pyrites.

ARSENID OF COPPER. PYRITES ALLIACEUS.

Arseniet of Copper. Weisskupfererz.

492. Massive and disseminated.

G.=4·5, Delametherie. *Lustre* metallic, glistening. *Color* between tin-white and brass-yellow. *Fracture* small and fine-grained. Brittle; easily frangible.

Before the blowpipe it evolves arsenical fumes and melts into a grayish-black slag. It has not been analyzed, but is supposed to consist of Arsenic, Copper, and Iron. According to Henkel, it contains 40 per cent of copper.

Obs. It is stated by Jameson to occur at Huel Garland, in Cornwall, and at several places in Germany and Hungary. It is a rare species.

VARIEGATED COPPER ORE. Pyrites erubescens.

Octahedral Copper Pyrites, *M.* Variegated Copper, *J.* Purple Copper, *P.* Liver-Colored Copper Ore. Buntkupfererz, *W.* and *L.* Bunter Kupferkies, *Haus.* Cuivre Pyriteux Hepatique, *H.*

493. *Primary form :* the regular octahedron. *Secondary forms :* figs. 1, 2, and 3, Pl. I. *Cleavage,* traces parallel with the faces of the primary. *Compound crystals :* fig. 129, Pl. II. *Imperfect crystallizations :* structure granular, strongly connected.

H.=3. G.=5·003. *Lustre* metallic. *Streak* pale, grayish-black, and slightly shining. *Color* between copper-red and pinchbeck brown. *Fracture* small conchoidal, uneven. Brittle. It speedily tarnishes when exposed.

It contains, according to Hisinger (Afhandlingar, iv. 359) and Phillips, (Annals of Phil. 2d ser. iii. 81,)

Copper	63·334	61·07
Iron	11·804	14·00
Sulphur	24·696	23·75
Silica	0·166=100, H.	0·50=99·32, P.

Before the blowpipe it blackens, and becomes red on cooling; at an increased temperature it fuses into a globule, attractable by the magnet. It is mostly dissolved by nitric acid.

Obs. It occurs with other copper ores in primitive and secondary rocks.

The crystalline varieties have been found only in Cornwall, and mostly in the mines of Tincroft and Dolcoath, near Redruth. Other foreign localities of massive varieties are at Ross Island, in Killarney, in Ireland; in cupriferous shale, in the Mansfield district; in Norway, Siberia, Hessia, Silesia, and the Bannat.

Massive varieties of variegated copper are found in the United States at Mahoopeny, near Wilkesbarre, Penn., and in other parts of the same state, in a cupriferous shale, associated in small quantities with vitreous copper; also in granite, at Chesterfield, Mass., also in New Jersey and Connecticut.

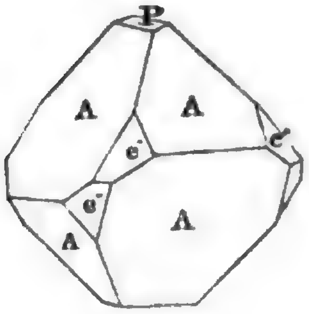
This species is a valuable ore of copper. Its name alludes to its liability to tarnish, and thus receiving a reddish hue.

COPPER PYRITES. Pyrites pyramidalis.

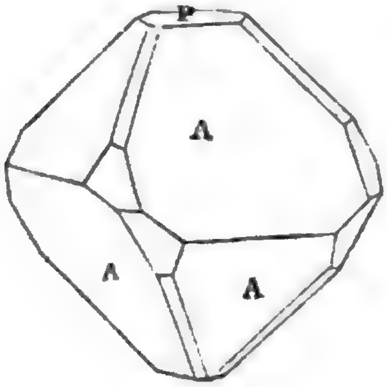
Pyramidal Copper Pyrites, *M.* Octahedral Copper Pyrites, *J.* Yellow Copper Pyrites. Pyritous Copper. Yellow Copper Ore. Kupferkies, *W.* and *L.* Cuivre Pyriteux.

494. *Primary form :* a square octahedron; A : A=101° 52′, Phillips. *Secondary forms :*

1.



2.



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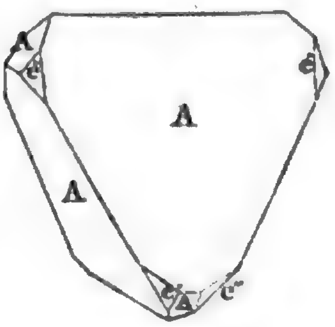
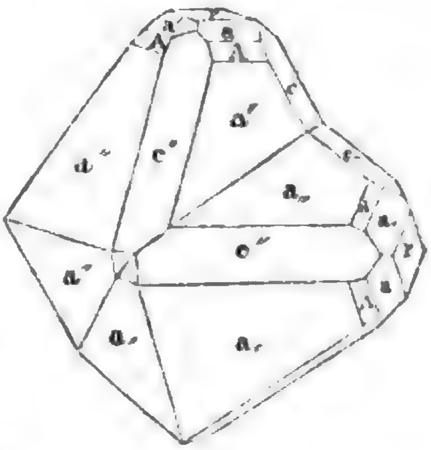


A : e=140° 46′. *Cleavage* sometimes distinct, parallel with e″; parallel with p, indistinct. *Compound crystals:* 1. Composition of the *third kind*—parallel to A, producing a form resembling fig. 129, Pl. II. Very complex forms result when this composition takes place, parallel to each of the faces A. 2. Composition of the *second kind*—parallel to e, (a plane truncating the terminal edge of A.) This form is represented in the annexed figure. A repetition of this composition parallel to each of the terminal edges, produces some of the most singularly complex and interesting forms in the mineral kingdom. These forms have been accurately delineated and described by Haidinger, in the third volume of Brewster's Journal, in a highly finished article on twin crystals, continued from Vol. I. of the same Journal, into several of the succeeding volumes. *Imperfect crystallizations:* globular, botryoidal, stalactitic, and other shapes—structure impalpably granular; granularly massive, often impalpable—particles strongly coherent.



H.=3·5—4. G.=4·159—4·160. *Lustre* metallic. *Streak* greenish-black—a little shining. *Color* brass-yellow; frequently subject to tarnish. Opaque. *Fracture* conchoidal, uneven. Rather sectile.

It contains, according to Rose, (Annals of Phil. 2d ser. vii. 355,) Phillips, (Annals of Phil. 2d ser. iii. 299,) Berthier, (Ann. des Mines, viii. 341,) and Thomson, (Min. i. 624,)

	Ramberg.			Cornwall.
Sulphur	35·87	34·46	36·3	34·655
Copper	34·40	31·20	32·1	33·640
Iron	30·47	30·80	31·5	31·535
Earthy Matter	0·27	1·10	—	0·555
	101·01, R.	97·56, P.	99·9, B.	100·385, T.

Before the blowpipe, on charcoal, it blackens, but becomes red on cooling. After a continued heat, it fuses into a globule which is magnetic. With borax it affords pure copper. It dissolves in nitric acid, excepting the sulphur, forming a green solution. A drop of liquid ammonia changes it to a deep blue.

Obs. Copper pyrites is the principal ore of copper at the Cornish mines. It is there associated with tin, variegated copper, galena, gray copper, and blende. The copper beds of Fahlun, in Sweden, are composed principally of this ore, which occurs in large masses, surrounded by a coating of serpentine, and imbedded in gneiss. At Rammelsberg, near Goslar, in the Hartz, it forms a bed in graywacke slate, and is associated with iron pyrites, galena, blende, and minute portions of silver and gold. The Kuprinz mine, at Freiberg, affords well defined crystals. It occurs also in the Bannat, Hungary, Thuringia, &c.

In the United States it has been found in several places, but nowhere in sufficient abundance to be worked. It occurs at the Southampton Lead Mines, Mass.; at the falls on the Connecticut, near Deerfield, Mass.; at Franconia, N. H., in gneiss; at Strafford and Shrewsbury, Vt., with magnetic pyrites. In Rossie, and the surrounding region, St. Lawrence Co., N. Y., it occurs in granite. It is also afforded by the Phœnix Copper Mines, in Fauquier Co., Virginia.

Cornwall has hitherto been one of the most important sources of copper. The following remarks on the mines in that region, are cited from Allan's Mineralogy, p. 261: "In the year ending 30th June, 1822, 104,522 tons of copper ore were raised in Cornwall, which sold for £663,085, and yielded 9140 tons of pure copper. In 1826, 117,308 tons were raised, which sold for £788,971, and yielded 9026 tons of copper; and in 1832, 137,357 tons of copper ore were raised, which sold for £825,612, and produced 11,947 tons of metallic copper. The whole produce of Great Britain and Ireland amounts to about 14,500 tons of copper, five sixths of which thus appear to be raised from the mines of Cornwall alone, and by much the larger portion, no doubt, in the form of copper pyrites. The enormous expense of fuel in that district, and the difficulty thereby occasioned of keeping the more extensive workings free of water, is however a most serious drawback on the profits of Cornish mining.

"Though copper pyrites occurs in vast profusion, it is by no means a rich one; what is picked for sale at Redruth rarely yielding 12, generally only 7 or 8, and occasionally so little as 3 or 4 per cent. of metal. In the latter case, such poverty of ore is only made up by its facility of transport, the moderate expense of fuel, or the convenience of smelting. Its richness may in general be judged of by the color; if of a fine yellow hue, and yielding readily to the hammer, it may be considered a good ore; but if hard and pale-yellow, it is assuredly a poor one, being mixed with iron pyrites."

Copper pyrites is readily distinguished from iron pyrites, which it somewhat resembles, by its inferior hardness; it may be cut by the knife, while iron pyrites will strike fire with the steel. The effects of nitric acid are also different. It differs from gold in being brittle, on account of which, it cannot be cut off in slices, like the latter metal.

CAPILLARY PYRITES. Pyrites capillaris.

Native Nickel, *M.* and *J.* Sulphuret of Nickel. Schwefel-Nickel, Haarkies *of the Germans.* Nickel Sulfuré, *Levy.*

495. In delicate capillary crystals.

H. about 3. *Lustre* metallic. *Color* brass-yellow, inclining to bronze-yellow and steel-gray. Opaque. Brittle.

It consists, according to Arfwedson, (Kong. Vet. Acad. Handl., 1822, p. 443,) of Nickel 64·35, and Sulphur 34·26=98·61. Before the blowpipe it fuses into a brittle metallic globule; it colors glass of borax violet-blue. It forms with nitric acid a pale-green solution.

Obs. It occurs in thin capillary crystals in the cavities, and among the crystals of other minerals, at Joachimstahl, in Bohemia, Johanngeorgenstadt, in Saxony, Andreasberg, Cornwall, and other places.

ORDER X.—GALINEA.

TIN PYRITES. CYPRITES CUBICUS.

Hexahedral Copper Glance, *M.* Sulphuret of Tin, *P.* Capreous Sulphuret of Tin, *Thom.* Bell Metal Ore. Zinnkies, *W.* Etain Sulfuré, *H.*

496. *Primary form :* the cube. Occurs commonly massive—structure granular, particles strongly coherent.

H.=4. G.=4·3—4·4. *Lustre* metallic. *Streak* black. *Color* steel-gray when pure ; often yellowish from the presence of copper pyrites. Opaque. *Fracture* uneven. Brittle.

According to Klaproth, (Beitrage, ii. 259, and v. 228,) it contains

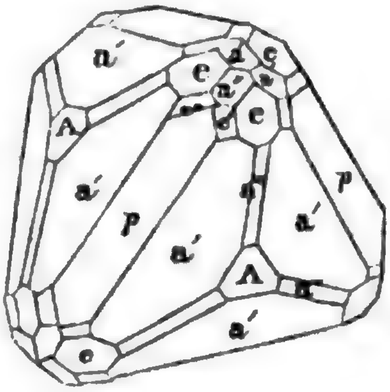
Sulphur	25	30·5
Tin	34	25·5
Copper	36	30·0
Iron	2=97	12·0=98.

Before the blowpipe, sulphur is expelled, and afterwards a black scoriaceous globule is obtained. It is soluble in nitro-muriatic acid, with the exception of a residue of sulphur.

OBS. This species has been observed only in Cornwall, and principally at Hull Rock, in the parish of St. Agnes, where it forms a considerable vein, and is accompanied by iron pyrites, blende, and other minerals. It frequently has the appearance of bronze, or bell metal, and hence the name *bell metal ore.*

GRAY COPPER ORE. CYPRITES TETRAHEDRUS.

Tetrahedral Copper Glance, *M.* and *J.* Gray Copper, Fahlerz, *P* Schwarzerz, *W.* Kupferfahlerz, Schwarzgiltigerz, *Haus.* Cuivre Gris, *H.*



497. *Primary form :* the octahedron. *Secondary forms :* crystals hemihedrally modified ; figs. 7, 16, 30, 32, 34, 35, 36. *Cleavage* in traces parallel to the faces of the octahedron. *Compound crystals :* composition parallel to a face of the octahedron. *Imperfect crystallizations :* structure granular—particles of various sizes, often impalpable, strongly connected.

H.=3—3. G.=4·798—5·104, Haidinger. *Lustre* metallic. *Streak* sometimes inclined to brown, but generally the same as the color. *Color* between steel-gray and iron-black. Opaque. *Fracture* subconchoidal, uneven. Rather brittle.

Its composition, according to Rose, who analyzed specimens from various localities, (Poggendorf's Annalen, xv. 576,) is given as follows in Thomson's Mineralogy, i. 627:

	Alsace.	Gersdorf.	Kapnik.	Clausthal.
Sulphur	26·83	26·33	25·77	24·73
Copper	40·60	38·63	37·98	34·48
Antimony	12·46	16·52	23·94	28·24
Arsenic	10·19	7·21	2·88	——
Iron	4·66	4·89	0·86	2·27
Zinc	3·69	2·76	7·29	5·55
Silver	0·60	2·37	0·62	4·97
Silica	0·41	—	—	—
	99·44	98·71	99·34	100·24

In another analysis of a specimen from Furstenberg, he obtained 17·71 per cent. of silver. A variety from Guadalcanal, in Spain, contains from one to ten per cent. of platinum, and another from Hohenstein, a little gold. Their comportment before the blowpipe is somewhat various. They all give off fumes of antimony or arsenic, finally melt, and after roasting, afford a globule of copper. When pulverized, they dissolve, with a little residue, in nitric acid.

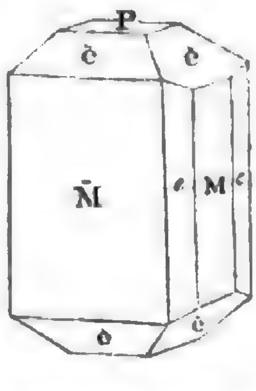
Obs. The Cornish mines near St. Austle, afford large tetrahedral crystals; their surfaces are commonly rough and dull. More brilliant and highly modified crystallizations occur at Andreasberg, in the Hartz, Kremnitz in Hungary, Freiberg in Saxony, Kapnik in Transylvania, and Dillenberg in Nassau. Those belonging to the *Fahlerz* (gray ore) of Werner, having a steel-gray color. The *Schwarzerz* is nearly iron-black. This variety occurs principally at the old mine of Schwatz, in the Tyrol, and at Kapnik in Transylvania; also at Clausthal in the Hartz, where it is imbedded in red manganese.

It is associated usually with copper pyrites, and is worked as an ore of copper. The weiss kupfererz, or cuivre pyriteux of Levy, appears to belong to this species.

BOURNONITE. CYPRITES RECTANGULUS.

Di-prismatic Copper Glance, *M.* Triple Sulphuret. Endellionite, *Bournon.* Schwarz Spiesglaserz, *W.* Bleifahlerz, Spiessglanz-bleierz, *Haus.* Bournonit, *L.* Radelerz. Antimoine Sulfure Plombo-cuprifère, *H.*

498. *Primary form:* a right rectangular prism. *Secondary form:* P : ē=133° 34′, P : ĕ=136° 50′, M̄ : *e*=138° 15½′, M̆ : *e*=131° 45½′, *e* : *e* (over M̄) =96° 31′. *Cleavage* parallel with M̄ and M̆, and both diagonals. *Compound crystals:* composition of the second kind, parallel to ĕ; cruciform crystals often occur, resulting from an aggregation of two pairs of molecules, according to this kind of composition. This may be represented by a figure similar to fig. 4, Pl. IV., by drawing the axes at right angles, and making, consequently, the



circumscribing parallelogram rectangular. Supposing the primary form to be a rhombic prism, with the planes ĕ as the primary lateral, this composition is represented by the figure referred to, without any change in it, except a little variation in the angles. These crystals cross at angles of 93° 30′, and 86° 20′, as necessarily follows from the inclination of P on ĕ, *Imperfect crystallizations:* structure granular, particles strongly connected.

H.=2·5—3. G.=5·766, Hatchett. *Lustre* metallic. *Streak* and *Color* steel-gray, inclining to blackish lead-gray, or iron-black. Opaque. *Fracture* conchoidal, or uneven. Brittle.

According to Rose, (Poggendorf's Annalen, xv. 573,) it consists of

	Crystals from Pfaffenburg.
Sulphur	20·31
Antimony	26·28
Lead	40·84
Copper	12·65=100·08,

and consequently, it is composed of one atom of sulphacid of antimony, (antimonious sulphacid,) one atom of sulpuret of lead, and one atom of the sulphuret of copper.

It decrepitates in the blowpipe flame and gives out white fumes of sulphur. Ultimately, it fuses into a black globule. In a strong heat, the charcoal is covered with the oxyd of lead. It readily dissolves in nitric acid.

Obs. The finest crystallizations of this species occur in the mines of Neudorf, in the Hartz, where they occasionally exceed an inch in diameter. It accompanies quartz, gray copper ore, and phosphorescent blende, at Kapnik, in Transylvania, in flattened crystals; at Servos, in Piedmont, it is associated with pearl spar and quartz. Other localities are at Braunsdorf and Gersdorf, in Saxony, Clausthal and Andreasberg, in the Hartz, &c.; also Endellion near Redruth, in Cornwall, where it was first found, and whence it was called *Endellionite*, by Count Bournon. It has since been named in compliment to this distinguished mineralogist.

TENNANTITE. Cyprites dodecahedrus.

Quart. Journ. vii. 95.

499. *Primary form:* the rhombic dodecahedron. *Secondary forms:* figs. 5, 6, 32, 36, Pl. I. *Cleavage* parallel with the faces of the primary, imperfect. Has not been observed massive.

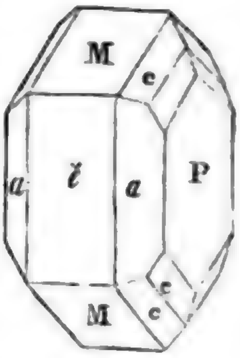
H.=3·5—4. G.=4·375—4·491. *Lustre* metallic. *Streak* reddish-gray. *Color* blackish lead-gray. *Fracture* uneven.

It contains, according to Phillips, (Phil. Mag. x. 157,) Copper 45·32, Arsenic 11·84, Iron 9·26, Sulphur 28·74, Silica 5. Before the blowpipe it decrepitates slightly, burns with a blue flame, emits copious arsenical fumes having an alliaceous odor, and finally fuses into a black scoria, which acts upon the magnet.

Obs. This species has only been observed in the Cornish mines, particularly near Redruth and St. Day. It commonly occurs in very splendent crystals investing other ores of copper.

VITREOUS COPPER. CYPRITES RHOMBICUS.

Prismatic Copper Glance, *M.* Sulphuret of Copper. Disulphuret of Copper, *M.* Glance Copper. Kupferglas, *W.* Kupferglanz, *Haus.* and *L.* Cuivre Sulfuré, *H.*



500. *Primary form:* a right rhombic prism; M : M=119° 25′. *Secondary form:* M : ĕ=120° 13′, M : e=152° 56′, M : e′=122° 44′. *Cleavage* indistinct parallel to M. *Compound crystals:* stellated forms similar to those of Arragonite; very frequent. *Imperfect crystallizations:* structure granular, particles of various sizes, usually small and often impalpable.

H.=2·5—3. G.=5·5—5·8; 5·7022, Thomson. *Lustre* metallic. *Streak* and *Color* blackish lead-gray; often tarnished blue or green; streak sometimes shining. *Fracture* conchoidal. Sectile.

According to Klaproth, (Beit. ii. 279, and iv. 37,) and Thomson, (Min. i. 599,) this mineral contains

Sulphur	18·50	22·0	20·62
Copper	78·50	76·5	77·16
Iron	2·25	0·5	1·45
Silica	0·75=100, K.	——=99, K.	——=99·23 T.

In the oxydizing flame of the blowpipe it melts, gives out fumes of sulphur, and emits glowing drops with a noise. In the reducing flame it becomes covered with a coating and does not melt. If the sulphur is driven off, a globule of copper remains. In heated nitric acid the copper is dissolved, and the solution assumes a green color; the sulphur is precipitated.

OBS. Cornwall affords splendid crystals of this species, where it occurs in veins and beds with other ores of copper. Some of the Cornish collections contain elegant suites of this beautiful though complicatedly crystallized mineral. The compact and massive varieties occur in Siberia, Hessia, Saxony, the Bannat, &c.

In the United States, compact varieties occur in the red sandstone formation at Simsbury and Cheshire, Conn.; also at Schuyler's mines, N. Y. A fine vein has lately been discovered at Bristol, Conn. In Virginia, it occurs in the U. S. copper mine district, Blue Ridge, Orange Co.

The argent en epis or Cuivre speciforme, of Haüy, which is merely vegetable matter impregnated with this ore, occurs at Mahoopeny, Penn.

BLUE COPPER.

Kupferindig.

501. Massive; in spheroidal forms with a crystalline surface.

Lustre resinous, faint. *Streak* lead-gray, shining. *Color* indigo-blue or darker. Opaque. Sectile.

Before the blowpipe it burns, before becoming red hot, with a blue flame, and fuses into a globule, which is strongly agitated and emits sparks; finally it yields a button of copper.

It contains, according to Walchner, Copper 64·77, Sulphur 32·64, Lead 1·05, Iron 0·46.

ANTIMONIAL COPPER.

Sulphuret of Copper and Antimony, *H. Rose*, Ann de Poggendorf, XXXV. 357.

502. Occurs in small aggregated prisms, which, according to M. G. Rose, are right rhombic, with their edges deeply truncated.

H.=3—4. G. at least 4·474. *Lustre* metallic. *Streak* black. *Color* between lead-gray and iron-gray. Opaque. *Fracture* conchoidal.

It contains, according to H. Rose, Copper 24·46, Iron 1·39, Antimony 46·81, Lead 0·56, Sulphur 26·34=99·56. The iron is supposed to exist in it, in the state of pyritous copper, and the lead, in that of feather ore. It is always covered with a thin coat of copper pyrites.

Obs. It occurs in nests in the mine of gray antimony, at Wolfsberg, in the Hartz.

EUCAIRITE. Lunites Selenicus.

Seleniuret of Silver and Copper, *P.* Argentiferous Seleniet of Copper. Eukairite, *Berzelius* and *L.* Selenkupfer Silber *of the Germans*. Cuivre Sélenié Argental, *H.*

503. Massive; in thin superficial black metallic films, staining the calcareous spar in which it is contained.

Soft. *Lustre* metallic. *Streak* shining. *Color* between silver-white and lead-gray.

According to Berzelius, (Afhandlingar, iv. 136,) it contains Silenium 26, Copper 23·05, Silver 38·93, foreign earthy matter 8·90=96·88. Before the blowpipe it gives out copious fumes of selenium, attended with the odor of horse-radish; and on charcoal, fuses readily into a gray metallic globule, which colors borax green, leaving a bead of selenid of silver. It dissolves in boiling nitric acid.

Obs. It has been found only in small quantities in the Skrickerun copper mine in Smaland, Sweden, in a serpentine kind of rock, imbedded in calcareous spar. It was discovered and analyzed by Berzelius, and thus named from ευ and καιρος, *opportunely*, because the mineral was found soon after the discovery of selenium.

STROMEYERITE. Lunites Cupricus.

Argentiferous Copper Glance, *J.* Sulpho-Cuprite of Silver, *Thom.* Argentiferous Sulphuret of Copper. Cupreous Sulphuret of Silver. Sulphuret of Silver and Copper. Silber-kupferglanz *of the Germans*. Cuivre Sulfuré Argentifère.

504. Massive; structure impalpably granular.

H.=3—4. G.=4·258. *Lustre* metallic. *Streak* shining. *Color* steel-gray. *Fracture* subconchoidal. Sectile, according to Stromeyer.

It contains, according to Stromeyer's analysis, (Gilbert's Annalen, liv. 114,) Sulphur 15·782, Silver 52·272, Copper 30·478, Iron 0·333=98·865. Easily fusible. The blue solution, obtained with nitric acid, affords indications of copper, when a plate of iron is dipped into it, and also precipitates silver upon an immersed copper plate.

Obs. This species is of rare occurrence. It is found associated with copper pyrites at Schlangenberg, near Colivan, in Siberia. A variety has been observed at Combavalla, in Peru, which contains some iron. It was first described and recognized as a peculiar species by Prof. Stromeyer.

VITREOUS SILVER. Lunites dodecahedrus.

Hexahedral Silver Glance, *M.* and *J.* Sulphuret of Silver, Vitreous Silver, *P.* Glaserz, *Haus.* Silberglanz, *L.* Argent Sulfuré, *H.*

505. *Primary form:* the rhombic dodecahedron. *Secondary forms:* figs. 1—9, inclusive, Pl. I., also 14, 15, 16. *Cleavage* traces parallel to the faces of the dodecahedron. *Imperfect crystallizations:* reticulated, arborescent, and filiform; also amorphous.

H.=2—2·5. G.=7·196—7·365. *Lustre* metallic. *Streak* and *color* blackish lead-gray; streak shining. Opaque. *Fracture* imperfect and small subconchoidal, uneven.

By Klaproth's analysis, (Beitrage, i. 162,) it contains Silver 85, and Sulphur 15=100. A fragment before the blowpipe intumesces, and soon affords a globule of silver. It is soluble in dilute nitric acid, and when isolated and rubbed, acquires resinous electricity.

Obs. This important ore of silver occurs in Europe, principally at Annaberg, Joachimstahl, and other mines of the Erzgebirge, Schemnitz and Cremnitz, in Hungary, and at Freiberg. At the last place it accompanies other silver ores, in veins traversing gneiss. The silver of Mexico is obtained principally from this ore.

TELLURIC SILVER. Lunites Telluricus.

Bitelluret of Silver, *Thom.* Tellur-Silber, *of the Germans.*

506. In coarse grained masses.

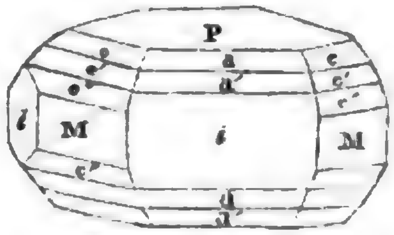
H.=2—2·5. G.=8·412—8·465. *Lustre* metallic. *Color* between lead-gray and steel-gray.

It contains, according to G. Rose, (Poggendorf's Annalen, xviii. 64,) Silver 62·37, Tellurium 36·92, and Iron 0·37=99·66. Before the blowpipe, on charcoal, it fuses into a black globule, which on cooling, after the action of the reducing flame, presents points or dendrites of silver on its surface. When heated in a glass tube it melts and gives a yellow color to the glass. Fused with carbonate of soda a globule of pure silver is obtained.

Obs. It occurs in the new mine of Sawodinski, about forty wersts from the rich silver mine of Siränowski, on the river Buchthorma, in Siberia, where it is found in a talcose rock, containing small quantities of iron pyrites, black blende, and copper pyrites. Specimens in the museum of Barnaul, on the Ob, where this mineral was first observed, were a cubic foot in size. It was first described and analyzed by Mr. G. Rose.

GRAPHIC TELLURIUM. Lunites Auricus.

Prismatic Antimony Glance, *M.* Graphic Gold. Schrifterz. Tellure Natif Auro-argentifere, *H.*



507. *Primary form:* a right rhombic prism; M : M=107° 44′. *Secondary form:* P : a=141° 30′, P : a′=129° 12′, P : e=151° 40′, P : e′=136° 42′, P : e″=132° 45′. *Cleavage* highly perfect parallel with M; less so parallel with P. *Compound crystals:* prismatic crystals

intersect at 68° and 120°, nearly. *Imperfect crystallizations:* structure imperfectly columnar and granular.

H.=1·5—2. G.=5·723. *Lustre* metallic. *Streak* and *Color* pure steel-gray. *Fracture* uneven. Very sectile.

It contains, according to Berzelius, (Kong. Vet. Acad. Handl., 1828, p. 113,) Tellurium 52, Silver 11·33, Gold 24, Iron 1·50=88·83, together with some copper, iron, antimony, sulphur, and arsenic. It fuses easily, tinging the flame greenish-blue, and covering the charcoal with a white oxyd; finally a ductile metallic globule is obtained. It dissolves in nitric acid.

Obs. It occurs with gold at Offenbanya, in Transylvania, in narrow veins, which traverse porphyry; also at Nagyag, in the same country.

Its name alludes to the peculiar disposition of the crystals, which present an appearance like writing characters.

The large amount of gold it contains, renders it a highly valuable ore.

POLYBASITE. Lunites rhombohedrus.

508. *Primary form:* a rhombohedron. Occurs usually in short and tabular hexagonal prisms. Terminal planes striated parallel to the alternately terminal edges. *Cleavage* not observable. Occurs also massive.

H.=2—3. G.=6·214. *Lustre* metallic. *Streak* black. *Color* iron-black. Opaque. *Fracture* uneven.

According to H. Rose, (Poggendorf's Annalen, xv. 575,) it contains

Sulphur	17·04
Silver	64·29
Antimony	5·09
Arsenic	3·74
Copper	9·93
Iron	0·06=100·15.

Obs. It occurs in the mine at Guanaxuato, in Mexico; also at Guansamez, in Durango, with copper pyrites and calcareous spar.

BRITTLE SILVER ORE. Lunites rhombicus.

Prismatic, Melane Glance, *M.* Brittle Silver Glance. Black Silver. Brittle Sulphuret of Silver. Trisulpho-Antimoniate of Silver. Sprodglaser, *W.* Sprodglanzerz, *Haus.* Argent Noir, Argent Antimonié Sulphuré Noir, *H.* Argent Sulphuré Fragile.

509. *Primary form:* a right rhombic prism; M : M=115° 39′, M : e=142° 10′, e : e (over M)=104° 19′, *a* : *a* (over ĕ)=107° 47′, P : *a*=126° 6½′. *Cleavage* imperfect and interrupted, parallel to M and ĕ. *Compound crystals:* composition of the *first kind*, producing forms similar to those of white lead ore and Arragonite; very frequent. *Imperfect crystallizations:* structure granular—particles strongly coherent.

H.=2—2·5. G.=6·269, specimen from Przibram. *Lustre* metallic. *Streak* and *Color* iron-black. *Fracture* uneven. Sectile.

According to Rose, (Poggendorf's Annalen, xv. 475,) it contains Sulphur 16·42, Antimony 14·68, Silver 68·54, Copper 0·64=100·28. Before the blowpipe it fuses and gives out fumes of sulphur and antimony, and is reduced to a dark-colored metallic globule, which may be further reduced by the addition of soda or silica. It is soluble in dilute nitric acid.

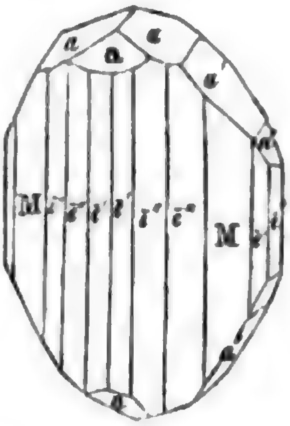
Obs. It occurs in veins with other silver ores in Freiberg, Schneeberg, and Johanngeorgenstadt, in Saxony, at Przibram and Ratieborzitz, in Bohemia, at Schemnitz and Kremnitz, in Hungary, at Andreasberg, in the Hartz, at Zacatecas, in Mexico, and in Peru.

The *schwarzgiltigerz*, of Werner, includes the compact varieties of this species, and his *weiss-giltigerz* is merely a mechanical mixture of brittle silver, galena, and gray antimony.

It is a valuable ore of silver.

ANTIMONIAL SULPHURET OF SILVER. Lunites peritomus.

Peritomous Antimony Glance, *M.* Sulphuret of Silver and Antimony, *P.* Schwefel Schilfglaserz, *Freisleben.* Silver und Antimon. Argent Sulfuré Antimonifère et Cuprifère, *Levy.*



510. *Primary form:* a right rhombic prism; M : M=100° 8′. *Secondary form : a : a*=130° 8′, *a″ : a″*=122° 15′, ĕ : *a″*=118° 53′, M : ĕ′=146° 30′, M : ĕ″=160° 30′, M : ĕ‴=170° 10′. M, longitudinally striated. *Cleavage* perfect, parallel with M.

H.=2—2·5. G.=5·5—5·6. *Lustre* metallic. *Color* light steel-gray, inclining to silver-white. Yields easily to the knife.

It is supposed to consist chiefly of Antimony, Sulphur, Silver, and Copper. Before the blowpipe it emits copious white vapors and a slight sulphureous odor, after which, a white metallic globule remains.

Obs. Occurs with vitreous silver, spathic iron, and galena, in the Himmelfurst mine, at Freiberg in Saxony, and Kapnik in Transylvania.

MOLYBDIC SILVER. Lunites Molybdicus.

Molybdena Silver, *J.* Molybdic Silver, *P.* Molybdan Silver, *W.*

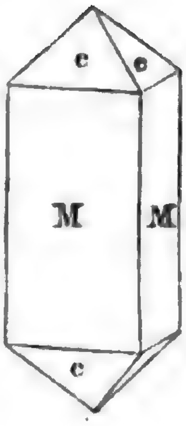
511. *Primary form:* a rhombohedron. *Cleavage* perfect, parallel with R.

Soft. G.=7·2—8. *Lustre* metallic. *Streak* dark iron-black. *Color* pale steel-gray. Electric when in thin laminæ.

GRAY ANTIMONY. Lycites diatomus.

Prismatoidal Antimony Glance, *M.* Sulphuret of Antimony, *P.* Sesquisulphid of Antimony, *Thom.* Hyp-Antimonous Sulphacid. Grauspiessglaserz, *W.* Grauspiessglanzerz, *Kaus.* Antimoine Sulfuré, *H.* Stibium, Στιμμι. Πλατυόφθαλμον. Leo Ruber. Plumbum Nigrum, *Vetr.* Lupus Metallorum.

512. *Primary form :* a right rhombic prism; M : M=90°



45′. *Secondary form:* M : e=155° 29′, P : P=109° 16′, and 108° 10′. Lateral planes deeply striated longitudinally. *Cleavage* highly perfect, parallel with the shorter diagonal. *Imperfect crystallizations:* structure columnar, particles of various sizes, usually thin; structure granular, impalpable, strongly connected.

H.=2. G.=4·516, Haüy; 4·62, Mohs. *Lustre* metallic. *Streak* and *Color* lead-gray, inclining to steel-gray; subject to tarnish. *Fracture* small subconchoidal. Sectile. Thin laminæ a little flexible.

It consists of

Antimony	74·06	74	73·77
Sulphur	25·94=100, Davy.	26=100, Bergmann.	26·23=100, Thomson.

It fuses readily in the flame of a candle; before the blowpipe it is absorbed by the charcoal, emitting at the same time white fumes and a strong sulphureous odor.

Obs. Gray antimony occurs with spathic iron in beds, but generally in veins. It is often associated with blende, heavy spar, and quartz.

It is met with in veins at Wolfsthal, in the county of Stollberg, in the Hartz, and at Posing, near Presburg, in Hungary. Its most celebrated localities, however, are Felsobanya, Schemnitz, and Kremnitz, in Hungary, where it often occurs in diverging prisms several inches long, accompanied by crystals of heavy spar and other mineral species. At Dumfriesshire it occurs fibrous and laminated; at Cornwall, massive; and compact, at Magurka, in Hungary.

This ore affords nearly all the antimony of commerce. The crude antimony of the shops is obtained by simple fusion, which separates the accompanying rock. From this product, most of the pharmaceutical preparations of antimony are made, and the pure metal extracted. This ore was employed by the ancients for coloring their hair, eyebrows, eyelashes, and edges of the lids; and as this last application was intended to increase the apparent size of the eye, they called the ore *πλατυοφθαλμον*, from *πλατυς*, *broad*, and *οφθαλμος*, *eye*. According to Dioscorides, it was prepared for this purpose by enclosing it in a lump of dough, and then burying it in the coals till reduced to a cinder. It was then extinguished with milk and wine, and again placed upon coals and blown till ignition; after which the heat was discontinued, lest, as Pliny says, "plumbum fiat," *it become lead.* From this we may infer, that the metal antimony was occasionally seen by the ancients, though not recognised by them as distinct from lead. (Moore's Ann. Min., p. 52.)

BERTHIERITE. Lycites Berthieri.

Haidingerite *of Berthier.* Berthierit, *Poggendorf.*

513. In elongated prisms or massive; a pretty distinct longitudinal cleavage.

Lustre metallic, less splendent than gray antimony. *Color* dark steel-gray, inclining to pinchbeck-brown; surface often covered with iridescent spots.

It contains, according to Berthier, (Ann. de Ch. et de Ph. xxxv. 351,) Sulphur 28·3, Antimony 48·3, Iron 14·9, Zinc 0·3, Quartz 3·2, Iron Pyrites 3·2=98·2. It fuses readily before the blowpipe, gives out fumes of antimony, and forms a black slag, which acts on the magnet. It dissolves readily in muriatic acid, giving out sulphuretted hydrogen.

Obs. It occurs at Charzelles, in Auvergne, associated with quartz, calcareous spar, and iron pyrites. It yields antimony of so inferior quality, that manufacturers cannot use it. It was first recognized and analyzed by Berthier. Berthier has lately described two other ores of antimony, (Memoires par Berthier, ii. 273,) which have the following characters.

The first has a fibrous texture, cross fracture granular, and almost dull. The color is grayish blue, but less blue and having less lustre than gray antimony. It contained Gangue 6·0, Sesquisulphuret of antimony 33·7, and Sulphuret of Iron 6·3. It occurs in the mine of Martouret, near Chazelle.

The other has an iron-gray color, and a granular and fibrous structure. It contained Quartz 7, Sesquisulphuret of Antimony 75, Sulphuret of Iron 18. It is found at Aglar, in the department of La Creuse. These, however, may possibly be varieties of one another.

ZINKENITE. Lycites Zinkeni.

G. Rose, Poggendorf's Annalen, VII. Brewster's Journal, VI. 17.

514. *Primary form:* a hexagonal prism. *Secondary form:* the primary terminated by a low hexagonal pyramid. P : e=102° 42′. Lateral faces longitudinally striated. G. Rose found in some instances, the interfacial angle M : M equal to 120° 39′, and hence conjectures, that the primary is a rhombic prism of this angle, and that the observed crystals are compound forms similar to fig. 3 or 6, Pl. IV. The crystals are usually in groups, sometimes forming fibrous and massive varieties. *Cleavage* not observable.

H.=3—3·5. G.=5·303. *Lustre* metallic. *Streak* and *Color* steel-gray. Opaque. *Fracture* uneven.

It contains, according to H. Rose, (Poggendorf's Annalen, viii. 99,) Sulphur 22·58, Lead 31·84, Copper 0·42, Antimony 44·39=99·23. Heated alone on charcoal it decrepitates briskly, and fuses as readily as gray antimony, affording small metallic globules, which are soon volatilized, and the charcoal is covered with a white coating of oxyd of lead. With carbonate of soda it yields globules of metallic lead.

Obs. It occurs in the antimony mine of Wolfsberg, in the Hartz. Its groups of columnar crystals occur on a massive variety of the same species in quartz. These crystals sometimes exceed half an inch in length, and have a breadth of two or three lines; but frequently they are extremely thin and form fibrous masses. It was named in compliment to Mr. Zinken, the director of the Anhalt mines, by Dr. G. Rose, to whom we are indebted for the first description of it.

It much resembles gray antimony and Bournonite, but may be distinguished by its superior hardness and specific gravity.

JAMESONITE. Lycites acrotomus.

Axotomous Antimony Glance, *M.*

515. *Primary form:* a right rhombic prism; M : M=101° 20′, and 78° 40′. *Cleavage* highly perfect parallel with P. *Imperfect crystallizations:* structure columnar, particles delicate, straight, and parallel or divergent.

H.=2—2·5. G.=5·5—5·8; 5·564, Haidinger. *Lustre* metallic. *Streak* and *Color* steel-gray. Opaque. Sectile.

Its composition was determined as follows by H. Rose :

Sulphur	22·15	22·53
Antimony	34·40	34·90
Lead	40·75	38·71
Lead, with traces of Iron and Zinc,	——	0·74
Copper	0·13	0·19
Iron	2·30=99·73.	2·65=99·72.

Before the blowpipe, in an open tube, it affords a dense white smoke of oxyd of antimony.

Obs. It occurs principally in Cornwall, associated with quartz and minute crystals of Bournonite; occasionally also in Siberia, and it is said in Hungary. Its perfect cleavage at right angles with the vertical axis, is sufficient to distinguish it from the species it resembles. It was first ranked as a species by Mohs, and named in compliment to Prof. Jameson, of Edinburgh.

The Plumose antimonial ore, or feather ore of lead, *federerz* of the Germans, has been analyzed by M. H. Rose, and found to contain Sulphur 19·72, Antimony 31·04, Lead 46·87, Iron 1·30, Zinc 0·08=99·01, which differs from the composition of Jamesonite, in containing half an atom more of sulphuret of lead. It occurs of a lead-gray color, in long capillary crystals, filling the drusy cavities of quartz, much resembling a cobweb. It fuses almost instantly in the flame of a candle, evolving at the same time white fumes. It occurs in Saxony and Hungary, &c. The specimen analyzed by Rose, was from Wolfsberg, in the Eastern Hartz.

ARSENICAL ANTIMONY. LYCITES ALLIACEUS.

Arseniet of Antimony, *Thom.* Min. I. 84.

516. In reniform masses and amorphous; structure fine granular.

H.=2—4. G.=6·13, Thomson; 6·2. *Lustre* metallic, occasionally splendent; sometimes dull. *Color* tin-white, or reddish-gray.

According to Thomson's analysis (Min. i. 84,) of a specimen from Allemont, it contains Antimony 46·612, Arsenic 38·508, Loss 14·880.

Before the blowpipe it emits fumes of arsenic and antimony, and fuses into a metallic globule, which takes fire and burns away, leaving oxyd of antimony on the charcoal.

Obs. It occurs sparingly at Allemont; also at Przibram, in Bohemia, where it was observed by Zippe, in metallic veins, associated with blende, antimony, spathic iron, &c.

BOULANGERITE.

Sulphuret of Antimony and Lead, C. *Boulanger*, Ann. des Mines. VII. 1835.

517. In masses, exhibiting in the fracture a crystalline structure. G.=5·97. *Lustre* metallic. *Color* bluish-gray.

It contains, according to Boulanger,

Sulphuret of Antimony	35·0
Sulphuret of Lead	62·1
Sulphuret of Iron	1·9
Sulphuret of Copper	1·1=100·1.

Fuses readily before the blowpipe, with exhalations of sulphurous acid and fumes of the white oxyd of antimony. On charcoal, a yellow circle indicates the presence of lead. Easily attacked by nitric acid. Boiling strong muriatic acid decomposes it with the extrication of sulphuretted hydrogen.

Obs. Occurs quite abundantly at Molières department of Gard, in France.

GALENA. Plumbites cubicus.

Hexahedral Lead Glance, *M.* Sulphuret of Lead. Blue Lead. Bleiglanz, Blau-Bleierz, *W.* Bleischweif, *Haus.* Plomb. Sulfuré, *H.* Plumbum Galena, *Linn.*

518. *Primary form:* the cube. *Secondary forms:* figures from 1 to 23, on Pl. I., and frequently several of them combined in the same crystal. *Cleavage* highly perfect and easily obtained, parallel to the faces of the cube. *Compound crystals:* fig. 129, Pl. II.; the same kind of composition frequently repeated. *Imperfect crystallizations:* reticulated, tabular, and other imitative shapes; also massive, structure granular—particles of various sizes, sometimes impalpable; occasionally fibrous. *Pseudomorphs:* imitative of pyromorphite, &c.

H.=2·5—2·75. G.=7·532—7·652. *Lustre* metallic. *Streak* and *Color* pure lead-gray. Surface of crystals occasionally tarnished. *Fracture,* when obtainable, flat subconchoidal, or even. Easily frangible.

When pure, it contains Sulphur 13·34, Lead 86·66. Before the blowpipe it decrepitates, unless heated with caution, when it fuses, gives off sulphur, and at last affords a globule of pure lead.

Obs. Galena occurs in beds and veins, both in primary and secondary rocks. At Freiberg, in Saxony, it occupies veins in gneiss; at Clausthal and Neudorf in the Hartz, and at Przibram in Bohemia, it traverses similar veins in clay slate; at Feistritz, and other places in Stiria, it occurs in the same kind of rock in beds; at Sala, in Sweden, it forms veins in primitive limestone; through the gray-wacke of Leadhills and the Killas of Cornwall, are disseminated veins of this ore; and in transition or mountain limestone, occur the rich repositories of Derbyshire, Cumberland, and the northern districts of England, as also those of Bleiberg, and the neighboring localities in Carinthia. In the English mines it is associated with calcareous spar, pearl spar, fluor spar, heavy spar, Witherite, calamine, and blende.

The most extensive deposits of this ore in the United States, and probably in the world, are met with at various places on the Mississippi river, from the banks of the Arkansaw to Prairie Du Chien. The ore occurs in limestone, and also disseminated in clay. The appearances ordinarily presented at the mines near Potosi, are as follows: "The shafts descend perpendicularly fifteen or twenty feet through a tenacious red clay, intermixed with masses of sulphate of barytes and sulphuret of lead; then succeeds the soft gray rock, which the miners call sandstone, but which is an aggregate of small crystalline particles of carbonate of lime; this stratum lies horizontally, but the miners remark, that it is uncertain at what depth they will strike it, as its surface is extremely uneven, and marked by deep concavities. It has numerous drusy cavities lined with minute quartz crystals, and is traversed by veins in which these crystals occur, intermixed with barytes and galena. This stratum varies in thickness at different points where it has been pierced, from six or eight to fifteen or twenty feet. It is succeeded by red clay, barytes, &c., similar to the former; and near the surface of this, sometimes in it, and sometimes in the red clay, the largest quantities of lead have been found."* The lead is so very abundant, that the miners seldom excavate very extensive shafts; but if mining becomes difficult, they select some new spot for their diggings, where less labor is required. The lead mines of this extensive region furnished, from the year 1821 to 1833, inclusive, 63,845,740 lbs.

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* Remarks on the limestones of the Mississippi lead mines. By E. James, Ass't Surgeon, U. S. army, in Journ. Acad. Nat. Sc. of Philad. v. 376.

The ore is usually accompanied by heavy spar, blende, pyrites, quartz, and calcareous spar.

Galena also occurs at Cave-in-Rock, in Illinois, associated with fluor spar. A rich vein has been lately discovered at Rossie, in St. Lawrence Co., N. Y., traversing, nearly perpendicularly, the gneiss of the region. This vein varies from one to three or four feet in width, and consists mostly of the pure ore. Other deposits have been discovered in the same region, some apparently in the direction of the main vein, and others remote from it. It is associated with perfect crystallizations of calcareous spar, commonly presenting the form of the scalene dodecahedron. The ore of this region varies in its structure from fine granular to broad lamellar, and sometimes presents large and well-defined crystals. Southampton, Mass., affords small quantities of galena; also at Austin's mines, in Weythe Co., Walton's gold mines, in Louisa Co., and at other places in Virginia, it occurs in small quantities. An argentiferous variety occurs sparingly, at Monroe, Conn., which afforded Prof. Silliman, by cupellation, 3 per cent. of silver.

COBALTIC GALENA. Plumbites Cobalticus.

Cobaltic Lead Glance, or Cobaltic Galena, *J.* Cobalt-bleierz, *Haus.*

519. Occurs in minute moss-like groups of crystals, possessing cleavage; also massive.

Soft and sectile. Soils a little. G.=8·44. *Lustre* metallic and shining. *Color* lead-gray, inclining to blue. Opaque.

According to Du Menil, it contains Lead 62·89, Arsenic 22·47, Sulphur 0·47, Iron 2·11, Cobalt 0·94, Arsenical Pyrites 1·44=90·32. Before the blowpipe it decrepitates; it colors glass of borax a smalt-blue.

Obs. It occurs in a vein of clay-slate and brown spar, traversing gray-wacke, in one of the Clausthal mines, in the Hartz.

CLAUSTHALITE. Plumbites Selenicus.

Seleniuret of Lead. Seleniet of Lead. Selenblei, *of the Germans.* Plomb Seleniuré, *Levy.*

520. Occurs commonly in fine granular masses; in some specimens a foliated structure is apparent.

H.=2—2·5. G.=7·187. *Lustre* metallic. *Streak* dark-gray. *Color* lead-gray, somewhat bluish. Opaque. *Fracture* granular and shining. Rather sectile.

It contains, according to H. Rose and Turner,

Lead	71·81	70·98
Selenium	27·59	28·11
Cobalt	——=99·40, R.	0·83=99·92, T.

Before the blowpipe, in addition to the usual phenomena arising from the presence of lead, it gives off the odor of horse-radish, and deposits on the charcoal a reddish-brown substance. Heated in a glass tube, closed at one end, the selenium almost immediately sublimes, forming a red ring within the tube, and on heating the tube to redness, the ore fuses and the red ring partially disappears, and a white crystalline deposit remains.

OBS. Clausthalite much resembles a granular galena; but its color is somewhat peculiar in its slight tinge of blue. It occurs only massive in a vein of hematite, near Harzgerode, in the Hartz.

This ore is found at the Harzgerode, combined either mechanically or chemically with several other selenids.

Selenid of lead and cobalt closely resembles the above, and is probably a mechanical mixture. It contains Selenium 31·42, Lead 63·92, Cobalt 3·14, Iron 0·45=98·93.

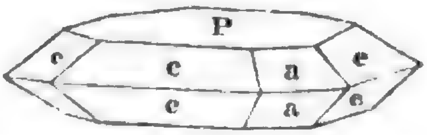
The *selenid of lead and copper* is also probably a mechanical mixture. It bears a close resemblance to the above. It contains Selenium 29·96, Lead 59·67, Copper 7·86, with less than one per cent. of Iron.

Another *selenid of lead and copper* had a violet color, and was very fusible. It was composed of Selenium 34·26, Lead 47·43, Copper 15·45, Silver 1·29, Oxyd of Lead and Iron 2·08=100·51, which indicates a compound of an atom each of selenid of lead and selenid of copper.

The following is the composition of two selenids of lead and mercury from the same locality, as determined by Rose: Selenium 24·97, Lead 55·84, Mercury 16·94 =97·75; the second, Selenium 27·98, Lead 27·33, Mercury 44·69=100. They closely resemble, in external appearance, the simple selenid of lead.

FOLIATED TELLURIUM. ELASMITES QUADRATUS.

Pyramidal Tellurium Glance, *M.* Bitelluret of Lead, *Thom.* Black Tellurium, *P.* Tellurium Glance. Nagyager-erz, *W.* Blattertellur, *Haus.* and *L.* Tellure Natif Aurifère et Plombifère, Tellure Natif Auro-Plombifère, *H.*



521. *Primary form:* a right square prism. *Secondary form:* P : e=110°, e : e=140°, P : a=118° 35′, a : a=122° 50′. *Cleavage* perfect, parallel with P. Occurs also granularly massive; particles of various sizes, sometimes slightly elongated, but generally foliated.

H.=1—1·5. G.=7·085. *Lustre* metallic. *Streak* and *Color* blackish lead-gray. Opaque. Sectile. Flexible in thin laminæ.

It contains, according to Klaproth (Beitrage, iii. 32) and Brandes, (Schweigger's Jahrbuch, v. 409,)

Tellurium	32·2	31·96
Lead	54·0	55·49
Gold	9·0	8·44
Silver	0·5	trace
Copper	1·3	1·14
Sulphur	3·0=100, K.	3·07=100·10, B.

From which it appears that it contains two atoms of tellurium and one atom of lead.

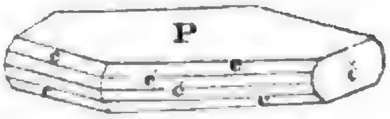
Before the blowpipe, on charcoal, it fuses readily into a malleable metallic button, tinging the flame at the same time blue, and covering the charcoal with white fumes. With borax it affords a bead of gold, with a little silver. It dissolves partially in nitric acid, and entirely in nitro-muriatic.

OBS. It occurs at Nagyag and Offenbanya, in Transylvania, in foliated masses and crystalline plates, accompanying, at the former place, silicate of manganese, blende, and gold; and at the latter, associated with antimony ores. A bitellurid of lead from Altai, has been described by Mr. G. Rose, (Pogg. Ann. xviii. 68,) which appears to be a purer variety of this species. An identity of crystalline form has not yet been shown, and we therefore have not incorporated its description with the above, but here append it.

G.=8·159. *Color* tin-white, much resembling that of native antimony. Sectile. Easily reduced to a powder. It contains Tellurium 38·37, Lead 60·85, and Silver 1·38. It is therefore nearly a pure bitelluret of lead. It may be wholly evaporised in the reducing flame, excepting a minute bead of silver. Its behavior under the blowpipe is very similar to that above described.

STERNBERGITE. Elasmites rhombicus.

Haidinger, Edin. Phil. Trans. XI. 1., and Brewster's Journal, VII. 242.



522. *Primary form:* a right rhombic prism; M : M=119° 30′. *Secondary form:* M : ĕ=120° 15′, e : ‚e=118°. *Cleavage* highly eminent, parallel with P. Occurs commonly in implanted crystals, forming rose-like aggregations. The crystals are sometimes compound.

H.=1—1·5. G.=4·215. *Lustre* of P, highly metallic. *Streak* black. *Color* pinchbeck-brown, with occasionally a violet-blue tarnish on e. Opaque. Thin laminæ flexible; may be smoothed down by the nail when bent, and in this respect resembling tin-foil. Very sectile. Leaves traces on paper like plumbago, which may be removed by caoutchouc.

According to Prof. Zippe, of Prague, (Poggendorf's Annalen, xxvii. 690,) it contains Silver 33·2, Iron 36, and Sulphur 30—99·2.

Heated in a glass tube it gives out a sulphureous odor, loses its lustre, and becomes dark-gray and friable. On charcoal, before the blowpipe, it burns with a blue flame, and melts into a globule which is generally hollow, has a crystalline surface, and is covered with metallic silver. This globule acts on the magnetic needle, and exhibits the properties of sulphuret of iron. With borax, a globule of silver may be obtained.

Obs. It occurs with ores of silver, particularly the red and brittle silver ores, at Joachimstahl, in Bohemia. It was first noticed by Haidinger in a specimen in the public collection at Prague, of which Count Caspar Sternberg is the patron and supporter, and named by him in compliment to this talented nobleman.

FLEXIBLE SILVER ORE. Elasmites rhomboideus.

Ferro-Sulphuret of Silver. Argent Sulfuré Flexible, *Bournon*.

523. Occurs in small tabular crystals, whose primary form, according to Brooke, is a right rhomboidal prism; M : T=125°. *Cleavage* very perfect in one direction. Also massive.

Very soft, yields readily to the knife. *Lustre* metallic. *Streak* shining. *Color* externally nearly black. Opaque. Flexible in thin laminæ.

Composed, according to Wollaston, of Silver, Sulphur, and a little Iron.

Obs. This rare species has been found in small quantities at Himmelsfurst in Saxony, and in Hungary.

MOLYBDENITE. Elasmites hexagonus.

Rhombohedral Molybdena Glance, *M.* Sulphuret of Molybdena, *P.* Bisulphide of Molybdenum, *Thom.* Molybden Glanz, *L.* Wasserblei, *W.* Molybdene Sulfuré, *H.*

524. *Primary form:* a hexagonal prism. *Secondary form:*

flat hexagonal prisms with replaced terminal edges. *Cleavage* eminent, parallel with P. Occurs commonly in foliated masses.

H.=1—1·5. G.=4·569, Karsten; 4·7385, Brisson. *Lustre* metallic. *Streak* similar to color, slightly inclined to green. *Color* pure lead-gray. Opaque. *Fracture* not observable. Thin laminæ highly flexible, but not elastic. Sectile, and almost malleable.

It contains, according to Bucholz, (Gehlen's Journ. iv. 60,) Molybdenum 60, and Sulphur 40=100. Neither fusion nor reduction is effected by the blowpipe, but sulphureous fumes are emitted, which are deposited on the charcoal. It dissolves with effervescence in nitric acid, excepting a gray residue. It deflagrates with nitre.

Obs. Molybdenite generally occurs imbedded in, or disseminated through, granite, gneiss, zircon-sienite, and other primitive rocks. Numedahl, in Sweden, and Arendal, in Norway, and Greenland, are the only places where it has been observed in hexagonal prisms. The secondary form is exceedingly rare. Altenberg, in Saxony, Schlaggenwald and Zinnwald, in Bohemia, are among its foreign localities. At Caldbeck Fell, in Cumberland, it is associated with tungstate of lime and apatite; it also occurs at several of the Cornish mines.

At Haddam, Conn., and the adjoining towns on the Connecticut river, it occurs in gneiss in crystals and large plates; at Saybrook it is associated with stilbite. At Westmoreland, Vt., there is a large vein of molybdenite, where it occurs in granular masses of considerable size, and is associated with crystals of white apatite. It is also found at Shutesbury, Mass., and Bowdoin, Me.

This mineral is readily distinguished from plumbago by its lustre and streak, and also with perfect facility by its behavior before the blowpipe and with acids.

SULPHURET OF BISMUTH. BISMITES RECTANGULUS.

Prismatic Bismuth Glance, *M.* **and** *J.* **Bismuthine. Wismuth Glanz,** *of the Germans.* **Bismuth Sulfuré,** *H.*

525. *Primary form:* a right rectangular prism. Lateral planes *e*, longitudinally striated; $\bar{\text{M}}$: *e*=about 135° 30′, *e* : *e*=91°. *Cleavage* parallel with the planes P $\bar{\text{M}}$ and $\breve{\text{M}}$, most perfect parallel with $\bar{\text{M}}$. The above angle, 91°, was obtained by Brooke, by a measurement of artificial crystals of sulphuret of bismuth. It occurs generally either in acicular crystals, or massive, with a foliated or fibrous structure.

H.=2—2·5. G.=6·549. *Lustre* metallic. *Streak* and *Color* lead-gray. Opaque. Sectile.

It contains, according to Rose (Gilbert's Annalen, lxxii. 192) and Wöhrle, (Jahres-Bericht, 1833, p. 177,)

Sulphur	18·72	18·28
Bismuth	80·98=99·70, R.	80·96=99·24, W.

It fuses in the flame of a candle; before the blowpipe it is volatilized, and covers the charcoal with a yellow areola, during which it continually throws out small drops in a state of incandescence. It dissolves readily in hot nitric acid, from which a white precipitate falls, on diluting it with water.

Foliated masses of sulphuret of bismuth accompany molybdenite and apatite in quartz, at Caldbeckfell in Cumberland. In Cornwall it occurs in acicular prisms with pyrites. At Johanngeorgenstadt, both massive and acicular crystallizations are met with in limestone. It is associated with cerium ore at Bastnaes in Sweden.

It is said to have been observed at Haddam, Conn., associated with chrysoberyl, beryl, automolite, garnet, and Columbite.

Unlike native bismuth, this ore does not effervesce in cold nitric acid. By this test, these two species may be distinguished, when other characters fail. It is also more fusible than galena, and less volatile than gray antimony.

ACICULAR BISMUTH. BISMITES ACICULARIS.

Acicular Bismuth Glance, Needle Ore, *J.* Plumbo-Cupriferous Sulphuret of Bismuth. Nadelerz, *of the Germans.* Bismuth Sulfuré, Plumbo-Cuprifère, *Levy.*

526. Occurs in imbedded acicular crystals; also massive.

H.=2—2·5. G.=6·125, John. *Lustre* metallic. *Color* blackish lead-gray, with a pale copper-red tarnish. Opaque. *Fracture* uneven.

It contains, according to John, (Gehlen's Jour. 2d ser. V. 227,)

Bismuth	43·20
Lead	24·32
Copper	12·10
Nickel ?	1·58
Tellurium ?	1·32
Sulphur	11·58
Gold	0·79=94·89.

Before the blowpipe it gives off fumes of sulphur, fuses, and emits numerous burning globules, and yields a bead of lead containing copper, which colors glass of borax greenish-blue.

OBS. Acicular bismuth occurs imbedded in white quartz, and accompanies gold, malachite, and galena, at Beresof, near Ekatherinenberg, in Siberia. It was first described and analyzed by John and Karsten.

Another variety of cupreous bismuth has been observed in certain mines near Wittichen, in Furstenberg. Its color is pale lead-gray, passing into tin-white—subject to tarnish; streak black; composition, according to Klaproth, Bismuth 47·24, Copper 34·66, Sulphur 12·58=94·48. It is associated with native bismuth and copper pyrites, which constitute veins traversing granite.

TELLURIC BISMUTH. BISMITES RHOMBOHEDRUS.

Telluret of Bismuth. Bornite.

527. *Primary form:* a rhombohedron. *Cleavage* perfect parallel with R.

G.=7·514, Baumgärtner; 7·5, Wörhle. *Lustre* metallic. *Color* pale steel-gray. Not very sectile. Laminæ elastic. *Soils* paper like molybdenite.

It contains, according to Wörhle and Berzelius,

Bismuth	59·84	58·30
Tellurium	35·24	36·05
Sulphur	4·92	4·32
Matrix	——=100, W.	0·75=99·42, B.

It fuses instantly in the blowpipe flame, and soon volatilizes, covering the charcoal with a yellow coating. It dissolves, when pulverized, in nitric acid, excepting the sulphur, which is precipitated.

OBS. It occurs in Hungary, at Deutsch Pilsen, with iron pyrites, calc spar, &c.

RIONITE. ZINCITES FLAMMANS.

Seleniet of Zinc. Selenid of Zinc.

528. Massive.

G.=5·56. *Lustre* metallic, or earthy. *Streak* blackish, when the color is lead-gray. *Color* lead-gray—to cochineal-red.

According to Del Rio, it contains Selenium 49, Zinc 24, Mercury 19, and Sulphur 1·5, with 6 per cent. of lime from the gangue. It appears to be, therefore, a biselenid of zinc, with some disulphuret of mercury; whether mechanically mingled or not, it is uncertain.

Before the blowpipe it burns with a fine violet-colored flame, and exhales selenium with the strong odor of horse-radish. When heated in a retort, selenium, mercury, and a little sulphur, sublime.

OBS. This species was discovered by Del Rio, in 1817, at Calebras, in the mining district of El Doctor, in Mexico.

ORDER XI.—ADELINEA.

MANGANBLENDE. Acarpia cubica.

Hexahedral Glance Blende, *M.* Sulphuret of Manganese, *P.* Manganblende, *Breit.* Schwarzerz, *Haus.* Manganglanz, *L.* Manganèse Sulfuré, *H.*

529. *Primary form:* the cube. *Secondary form:* the regular octahedron. *Cleavage* perfect parallel with the primary faces. Occurs also granularly massive.

H.=3·5—4. G.=3·95—4·014. *Lustre* submetallic. *Streak* green. *Color* iron-black, tarnished brown on exposure. *Fracture* uneven.

It contains, according to Klaproth, Vauquelin, and Arfwedson,

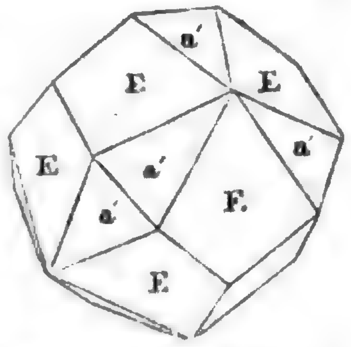
Protoxyd of Manganese	82	85	62·6
Sulphur	11	15	37·0
Carbonic Acid	5=98, K.	— =100, V.	— =99·6, A.

Only the thinnest edges are fused by means of the blowpipe. When pulverized and thrown into muriatic acid, or dilute sulphuric acid, sulphuretted hydrogen is evolved.

Obs. Manganblende occurs in veins, in the gold mines of Nagyag, in Transylvania, associated with tellurium, carbonate of manganese, and quartz.

BLENDE. Acarpia dodecahedra.

Dodecahedral Garnet Blende, *M.* Sulphuret of Zinc. Black Jack. Blende, *of the Germans.* Zinc Sulfuré, *H.* Pseudo-galena. Zincum sterile, *Linn.*



530. *Primary form:* the rhombic dodecahedron. *Secondary forms:* figs. 1, 6, 8, 9, 30, 32, Pl. I.; also the annexed figure, in which the acute solid angles are replaced by two instead of four secondary planes. These secondary planes would replace the alternate solid angles of the cube, three planes being situated on each, as in fig. 33, Pl. II. Sometimes this modification is accompanied by a truncation of the alternate obtuse solid angles of the dodecahedrons, which planes on the cube would occupy the unmodified solid angles of fig. 33, Pl. I. *Cleavage*

highly perfect parallel with the primary faces. *Compound crystals:* similar to fig. 129, Pl. II.; occurs parallel to the same faces (A, fig. 4, or a, fig. 8) in several of the secondary forms. This composition is often repeated. *Imperfect crystallizations:* botryoidal, and other imitative shapes—structure columnar—impalpable; also amorphous, with a similar structure.

H.=3·5—4. G.=4·027—4·078. *Lustre* adamantine—resinous. *Streak* white—reddish-brown. *Color* brown, black, yellow, red, green, none bright; yellow, when pure. Transparent—translucent. *Fracture* conchoidal. Brittle.

It contains, according to Arfwedson, (Kong. Vet. Acad. Handl., 1822, p. 438,) Berthier, (Ann. des Mines, ix. 420,) and Thomson, (Min. i. 540,)

		Brown.	
Zinc	66·34	63·0	66·000
Sulphur	33·66	33·6	32·628
Iron	——=100, A.	3·4=100, B.	1·372=100, T.

It is therefore a simple sulphuret of zinc. It often, however, contains a large portion of iron; in one specimen Thomson detected 20·74 per cent. It is infusible both *per se* and with borax. By a strong heat in the oxydating flame of the blowpipe, vapors of zinc are evolved, which coat the charcoal. It dissolves in nitric acid, during which sulphuretted hydrogen is disengaged. Some specimens exhibit a phosphorescence when struck with a steel, or by friction.

Obs. Blende occurs in both primary and secondary rocks, and is usually associated with galena; also with heavy spar, copper pyrites, fluor, spathic iron, and frequently it occurs in silver mines. Derbyshire, Cumberland, and Cornwall, afford the black varieties; also Transylvania, Hungary, and the Hartz. Sahla, in Sweden, Ratieborzitz, in Bohemia, and many Saxon localities, afford splendid black and brown crystals. A variety having a diverging fibrous structure, and presenting botryoidal forms, is met with at Fowey.

A yellowish-brown blende occurs abundantly with galena at Southampton, Mass. A black variety occurs at Monroe, Conn., with galena, wolfram, tungstate of lime, and magnetic pyrites. The Perkiomen lead mine, near Philadelphia, and the Missouri lead mines, afford this ore in abundance. It is also found in connection with the veins of galena in St. Lawrence Co., N. Y. Other localities are the Falls of Niagara, Walton's gold mine, Louisa Co., Virginia, the Ancram lead mine, Columbia Co., N. Y.

RED ANTIMONY. Cerasia rhomboidea.

Prismatic Purple Blende, *M.* Prismatic Antimony Blende, *J.* Rothspiesglanzerz, *W.* Rothspiesglanzerz, *Haus.* Antimon Blende, *L.* Antimoine Hydro-Sulfuré, Antimoine Oxydé Sulfuré, *H.*

531. *Primary form:* a right rhomboidal prism; M : T=101° 19′. *Secondary form:* primary with the lateral edges (*e*) deeply replaced. *Cleavage* highly perfect parallel with M. It usually occurs in tufts of capillary crystals, consisting of elongated, slender, six sided prisms. Also in flakes, resembling tinder, resulting from an interlacing of minute individuals.

H.=1—1·5. G.=4·45—4·6. *Lustre* adamantine. *Streak* brownish-red. *Color* cherry-red. Feebly translucent. Sectile.

According to H. Rose, it contains Antimony 74·45, Oxygen 4·27, Sulphur 20·47=99·19. It fuses readily on charcoal, and at last is entirely volatilized. In nitric acid it becomes covered with a white coating.

Obs. This rare mineral occurs in veins in quartz, accompanying gray and white antimony, at Malazka near Posing, in Hungary; at Braunsdorf, near Freiberg, in Saxony; and at Allemont, in Dauphiny. The tinder ore variety is found principally at Clausthal and Andreasberg, in the Hartz.

MIARGYRITE. Rubella obliqua.

Hemi-prismatic Ruby Blende, *M.* Bisulpho-antimoniate of Silver, *Thom.*

532. *Primary form:* an oblique rhombic prism; M : M=86° 4′, P : M=101° 6′. *Secondary forms:* similar to fig. 97, Pl. II.; lateral planes deeply striated. *Cleavage* parallel with M imperfect.

H.=2—2·5. G.=5·234. *Lustre* submetallic-adamantine. *Streak* dark cherry-red. *Color* iron-black. Opaque, except in thin splinters, which, by transmitted light, present a deep blood-red color. *Fracture* subconchoidal. Very sectile.

According to H. Rose, (Poggendorf's Annalen, xv. 469,) it contains Sulphur 21·95, Antimony 39·14, Silver 36·40, Copper 1·06, Iron 0·62=99·17. Before the blowpipe its action resembles that of the following species.

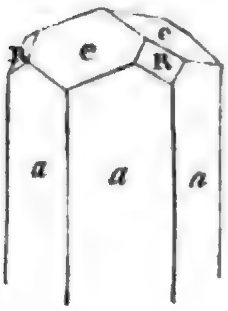
Obs. This rare species has been observed only in a mine at Braunsdorf, near Freiberg, in Saxony, associated with argentiferous arsenical pyrites. It was first distinguished from red silver ore by Mohs. Its name is derived from μειων, *less*, and ἀργυρος, *silver*, and was given it because it contained less silver than some kindred ores.

DARK RED SILVER ORE. Rubella rhombohedra.

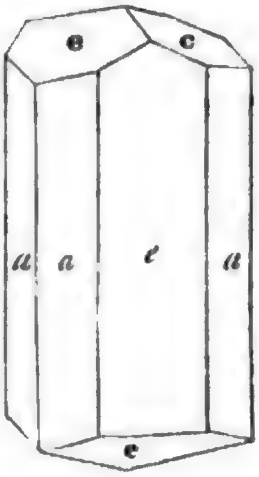
Rhombohedral Ruby Blende, *M.* Ruby Silver, *P.* Black Silver. Subsesquisulpho-Antimoniate of Silver, *Thom.* Ærosite, Rothgiltigerz, *W.* Dunkles Rothgültigerz, *G.* Argent Antimonié Sulfuré, *H.* Argentum Rubrum, *Linn.*

533. *Primary form:* an obtuse rhombohedron; R : R=108° 18′. *Secondary forms:*

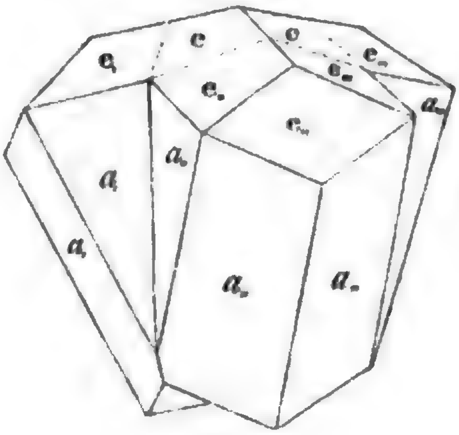
1.



2.



3.



R : e=144° 9′, e : e=137° 29′. The crystals are often differently modified at their two extremities. *Cleavage* parallel with R, sometimes pretty distinct. *Compound crystals:* composition of the *second kind;* 1. parallel to e, or a plane truncating the terminal edge; this composition taking place parallel with each plane e at one extremity of the crystal, gives rise to the form represented in fig. 3, which is composed of four individuals; 2. parallel with *e* or a plane truncating a lateral edge; composition of the *third kind*, parallel to the face *a*, fig. 121, which truncates the lateral angle. *Imperfect crystallizations:* structure granular, sometimes impalpable.

H.=2·5. G.=5·7—5·9, Breithaupt. *Lustre* metallic-adamantine. *Streak* cochineal-red. *Color* black, sometimes approaching cochineal-red. Translucent—opaque. *Fracture* conchoidal. Sectile, yielding readily to the knife.

According to Bonsdorf, (Kong. Vet. Acad. Handl. 1821, 338,) it contains Silver 58·949, Antimony 22·846, Sulphur 16·609, Earthy matter 0·299=98·703, from which Thomson deduces the above chemical name of this species given among the synonyms. It fuses and gives out fumes of antimony; ultimately a globule of silver is obtained. It partially dissolves in heated nitric acid.

Obs. The *dark red silver ore* occurs principally with calcareous spar, native arsenic and galena, at Andreasberg, in the Hartz. In Saxony, Hungary, Norway, and at Guadalcanal in Spain, are other localities. In Mexico it is worked extensively as an ore of silver.

It is highly valuable as an ore of silver. Cinnabar may be distinguished from this species, by its complete volatility under the blowpipe.

LIGHT RED SILVER ORE. Rubella florida.

Rhombohedral Ruby Blende, *M.* Lichter Rothgültigerz. Proustite.

534. *Primary form:* an obtuse rhombohedron; R : R=107° 36′. *Secondary form:* similar to fig. 116 and 119, Pl. II. *Compound crystals:* similar to the preceding species. Occurs also granularly massive.

H.=2—2·5. G.=5·422—5·53. *Lustre* adamantine. *Streak* cochineal-red, sometimes inclining to aurora-red. *Color* cochineal-red. Subtransparent—subtranslucent. *Fracture* conchoidal—uneven.

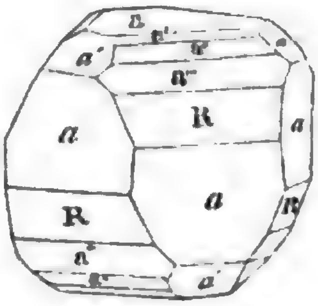
It contains, according to H. Rose, (Poggend. Annalen, xv. 473,) Silver 64·67, Arsenic 15·09, Sulphur 19·51, Antimony 0·69=99·96. Before the blowpipe its behavior is like the preceding species, except that fumes of arsenic are emitted.

Obs. It occurs with other ores of silver, galena, blende, pyrites, and arsenic, at Marienberg, Annaberg, and Johanngeorgenstadt, in Saxony, and at Joachimstahl, in Bohemia. A group of crystals from the last locality, several inches long, and weighing upwards of six pounds, is now in the National Museum at Prague.

It is an important ore of silver. Red orpiment, which it sometimes resembles, differs from it in having a yellow streak.

CINNABAR. Rubella peritoma.

Peritomous Ruby Blende, *M.* Sulphuret of Mercury. Zinnober. Quecksilber-Lebererz, *W.* Stinkzinnober Lebererz, *Haus.* Mercure Sulfuré, *H.* Κινναβαρις, *Theoph.* c. 103. Αμμιον, *Dioscor.* V. c. 109, 110. Minium. *Vitruv. Plin.*



535. *Primary form:* an acute rhombohedron; R : R=71° 47′. *Secondary form:* R : a'''=157° 20′. R horizontally striated. *Cleavage* parallel with *a*. *Compound crystals:* composition of the third kind—parallel with a, a plane truncating the terminal angle. *Imperfect crystallizations:* granularly massive—particles usually small, and often impalpable; sometimes forming superficial coatings.

H.=2—2·5. G.=8·098, a cleavable variety from Neurmarktel. *Lustre* adamantine, inclining to metallic in dark colored varieties, and to dull in friable varieties. *Streak* scarlet-red. *Color* cochineal-red, the darker varieties inclining to brownish-red, and lead-gray. Subtransparent—subtranslucent. *Fracture* subconchoidal, uneven. Sectile.

It contains, according to Klaproth, (Gehlen's Journal, v. 436, 440,)

	Neurmarktel.	Liver Ore from Idria.
Mercury	85·00	81·80
Sulphur	14·25=99·25.	13·75=95·55.

In the liver ore, which is a compact variety of a brown color, in addition to the above, Klaproth found Charcoal 2·30, Silica 0·65, Alumina 0·55, Iron 0·20, Copper 0·02, Water 0·73.

Before the blowpipe it volatilizes readily, when pure. It dissolves in nitric acid.

Obs. The *hepatic cinnabar* or *liver ore*, is an impure variety of this species; it sometimes affords a brownish streak in consequence of its impurities, and is occasionally slaty, though commonly granular or impalpable in its structure.

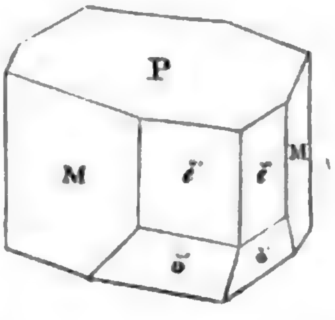
Cinnabar is usually associated in beds with native mercury, native amalgam, and occasionally only with calcareous spar and quartz. It has been observed in veins, with ores of iron.

The finest crystals of this species occur in the coal formations of Moschellandsberg and Wolfstein, in the Palatinate; also in Japan, Mexico, and Brazil. The most important beds of this ore are at Almaden in Spain, and at Idria in Carniola, where it is usually massive. It occurs at Richenau, in Upper Carinthia, in beds traversing gneiss; at Dunbrawa, in Transylvania, in gray-wacke; at Windisch Kappel, in Carinthia; at Neurmarktel, in Carniola. The variety *coralinerz*, from Idria, has a curved lamellar structure.

This ore is the great source of the mercury of commerce, from which it is obtained by sublimation. When pure, it is identical with the manufactured vermilion of commerce, which is a valuable pigment, and besides various other uses, is employed in coloring sealing wax. It was highly esteemed for its brilliancy of color by the ancients, and was employed as a paint for various sacred purposes.

REALGAR. Euchroa rubella.

Hemi-prismatic Sulphur, *M.* Red Orpiment or Ruby Sulphur, *J.* Red Sulphuret of Arsenic. Sulphide of Arsenic, *Thom.* Arsenous Sulphacid. Rothes Rauschgelb, *W.* Realgar, *Haus.* and *L.* Arsenic Sulfuré Rouge, *H.* Arsenicum Sandaraca, *Linn.* Σανδαρακη, *Theoph. Dioscor.* Sandaraca, *Plin. Vitr.*



536. *Primary form:* an acute oblique rhombic prism, M : M=74° 26′. *Secondary form:* $\breve{e}'$: $\breve{e}'$=113° 20′, P : $\breve{e}$ (plane truncating the edge between $\breve{e}'$ and $\breve{e}'$) =113° 16′. Occurs also granularly massive, particles of various sizes, strongly connected.

H.=1·5—2. G.=3·642, Breithaupt; 3·384, Brisson. *Lustre* resinous. *Streak* varying from orange-yellow to aurora-red. *Color* aurora-red or orange-yellow. Transparent—translucent. *Fracture* conchoidal, uneven. Sectile; yields to the nail.

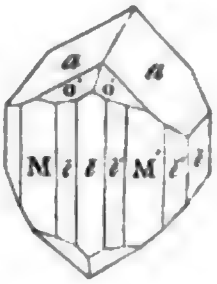
It contains Sulphur 29·96, and Arsenic 70·04=100. It fuses readily before the blowpipe and burns with a blue flame, and is dissipated in fumes of an alliaceous odor, with some sulphurous acid. By friction, it acquires negative electricity.

Obs. Fine crystallizations of this species have been observed with ores of silver and lead, at Felsobanya, in Upper Hungary, at Kapnik and Nagyag in Transylvania, at Joachimstahl in Bohemia, at Schneeberg in Saxony, and at Andreasberg in the Hartz. At Tajowa, in Hungary, it occurs in beds of clay, and at St. Gothard, in Switzerland, imbedded in dolomite. It has also been observed in the Vesuvian lavas, in minute crystals. Strabo speaks of a mine of *sandaraca* (the ancient name of this species) at Pompeiopolis in Paphlagonia.

Realgar has long been used as a pigment.

ORPIMENT. Euchroa aurea.

Prismatoidal Sulphur, *M.* Yellow Sulphuret of Arsenic. Sesquisulphide of Arsenic, *Thom.* Arsenic Sulphacid. Gelbes Rauschgelb, *W.* Rauschgelb, *Haus.* Auripigment, *L.* Arsenic Sulfuré Jaune, *H.* Resigallum. Auripigmentum, *Vitr.* 'Αρσενικὸν, *Dioscor.* Αῤῥενῖκον, *Theoph.* Arsenicum, *Plin.*



537. *Primary form:* a right rhombic prism; M : M=100° 40′. *Secondary form:* M : $\bar{e}$=140° 20′, M : $\breve{e}$=129° 40′, *a* : *a*=83° 37′, $\breve{e}$: *a*=138° 12′. *Cleavage* parallel with $\breve{e}$ highly perfect; parallel with $\bar{e}$ in traces; $\breve{e}$ longitudinally striated.

H.=1·5—2. G.=3·48, Haidinger; 3·4, Breithaupt. *Lustre* metallic-pearly upon the faces of perfect cleavage; elsewhere resinous. *Streak* yellow, commonly a little paler than the color. *Color* several shades of lemon-yellow. Subtransparent—subtranslucent. Sectile. Thin laminæ obtained by cleavage, flexible, but not elastic.

It contains Sulphur 39·08, and Arsenic 60·92. It burns with a blue flame on charcoal before the blowpipe, and emits fumes of sulphur and arsenic. Dissolves in nitric, muriatic, and sulphuric acids.

Obs. Orpiment occurs in small crystals imbedded in clay, near Neusohl, in Lower Hungary. It usually occurs in foliated and fibrous masses, and in this form is found at Kapnik in Transylvania, at Moldawa in the Bannat, and at Felsobanya in Upper Hungary, where it exists in metalliferous veins, associated with realgar and native arsenic.

The name orpiment, is a corruption of its Latin name auripigmentum, "*paint of gold*," which was so called in allusion to its color, and also because it was supposed to contain gold.

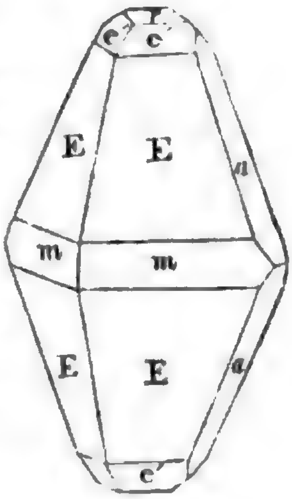
It is used as a pigment.

ORDER XII.—THEIINEA.

NATIVE SULPHUR. Sulphur pyramidalis.

Prismatic Sulphur, *M.* and *J.* Native Sulphur. Naturlicher Schwefel. Soufre, *H.* Θειον.

538. *Primary form:* a rhombic octahedron; E : E (adjacent in the same pyramid) =106° 38′, and 84° 58′, E : E (adjacent but in different pyramids) =143° 17′. *Secondary form:* m : m=101° 59′, m : E=161° 39′, E : *a*=132° 29′, e′ : e′ (adjacent) =127° 1′, p : e′=134° 53′, p : *a*=117° 48′. *Cleavage* parallel with E and m imperfect. *Compound crystals:* composition parallel with with *p*. *Imperfect crystallizations:* imitative shapes and amorphous; composed of concentric coats; massive structure granular—particles small, often impalpable, strongly coherent.



H.=1·5—2·5. G.=2·072, crystals from Spain. *Lustre* resinous. *Streak* sulphur-yellow—yellowish-white. *Color* sulphur-yellow, sometimes reddish or greenish. Transparent—subtranslucent. *Fracture* conchoidal, more or less perfect. Sectile.

It is pure sulphur, but is often contaminated with clay or bitumen. It burns with a bluish flame at a low temperature, with the strong odor of sulphurous acid. It becomes resinously electrified by friction. It is insoluble in water, and is not acted upon by the acids.

Obs. Sulphur is one of the dimorphous substances, since its crystalline form varies fundamentally with the temperature at which crystallization takes place. Crystallized from fusion, it presents obtuse oblique rhombic prisms, in which M : M=90° 32′, and P : ē (plane truncating the obtuse or front lateral edge) =95° 46′.

The great repositories of sulphur are either beds of gypsum and the associate rocks, or the regions of active and extinct volcanoes. In the valley of Noto and Mazzara in Sicily, at Conil near Cadiz in Spain, and Cracow in Poland, it occurs in the former situation. Sicily, and the neighboring volcanic isles, the Solfatara near Naples, the volcanoes of the Pacific ocean, &c., are localities of the latter kind. The crystals from Sicily are sometimes two or three inches in diameter. It is also deposited from hot springs in Iceland; and in Savoy, Switzerland, Hanover, and other countries, is met with in certain metallic veins. At Radoboy, near Crapina in Croatia, it occurs in imbedded spheroidal masses, which have a brownish tinge, owing to the presence of bitumen. Stromeyer detected selenium in a dark reddish colored sulphur of the Lipari islands.

The sulphur mines of Sicily, the crater of Volcano, and the Solfatara, near Naples, afford immense quantities of sulphur for commerce. Previous to becoming an article of commerce, it is purified by fusion or sublimation. The manufacture of gunpowder, of sulphuric acid, casts, cements, and various pharmaceutical preparations, are among the important processes in which sulphur is required.

CLASS III. HYPOGÆA.

ORDER I.—PITTINEA.

MELLITE. MELLIS PYRAMIDALIS.

Pyramidal Melichrone Resin, *M.* **Mellilite. Honey Stone. Mellate of Alumina. Honingstein**, *of the Germans.*

539. *Primary form:* a square octahedron; A : A=118° 4′. *Secondary form:* similar to fig. 55, Pl. I., also with the terminal or lateral solid angles truncated. *Cleavage* very indistinct, parallel with the primary faces. Occurs also in massive nodules.

H.=2—2·5. G.=1·55—1·597. *Lustre* resinous, inclining to vitreous. *Streak* white. *Color* honey-yellow, often reddish or brownish. Transparent — translucent. *Fracture* conchoidal. Sectile.

According to Klaproth (Beitrage, iii. 16) and Wöhler, it contains

Alumina	16	14·5
Mellic Acid	46	41·4
Water	38=100, K.	44·1=100, W.

In the flame of a candle it whitens, but does not take fire. It dissolves in nitric acid, and is decomposed by boiling in water.

OBS. Astern in Thuringia, is the only known locality of Mellite. It there occurs in a bed of earthy-brown coal, and is occasionally accompanied with small crystals of sulphur.

AMBER. SUCCINUM ELECTRUM.

Yellow Mineral Resin, *M.* **Bernstein**, *of the Germans.* **Succin**, *H.* **Succinum. Ηλεκτρον. Λυγκουριον. Lyncurion**, *Demostr.*

540. Occurs in irregular masses, destitute of cleavage.

H.=2—2·5. G.=1·081. *Lustre* resinous. *Streak* white. *Color* yellow, sometimes reddish, brownish, and whitish. Transparent —translucent.

According to Drapier and Ure, it contains

Carbon	80·59	70·68
Hydrogen	7·31	11·62
Oxygen	6·73=94·63, D.	7·77=90·07, U.

Drapier also detected minute portions of lime, alumina, and silica. It burns readily with a yellow flame, emitting an agreeable odor, and leaves a black shining carbonaceous residue. It becomes electric by friction. It is soluble in alcohol.

Obs. Amber occurs in the greatest abundance on the Prussian coast, in a bed of bituminous coal, whence it is washed out by the waves and thrown ashore. It is also obtained at the same place by sinking a shaft into the coal. It occurs also along the whole line of the Baltic coast, at Courland, Livonia, Pomerania, and in Denmark; also near Catania on the Sicilian coast, sometimes very peculiarly tinged blue. At Hasen Island, in Greenland, it also occurs in brown coal; also near Paris, in clay, and in China.

It has been often found in various parts of the green sand formation of the United States, either loosely imbedded in the soil, or engaged in marl or lignite, as at Gay Head or Martha's Vineyard, near Trenton in New Jersey, at Camden in Pennsylvania, and at Cape Sable, near Magothy river, in Maryland.

The vegetable origin of amber is now fully ascertained. This is inferred, both from its native situation with coal, and from the occurrence of insects encased in it. Of these insects, some appear evidently to have struggled after being entangled in the then viscous fluid, and occasionally a leg or wing is found some distance from the body, which had been detached in the struggle for escape; frequently also a wing or leg is found alone, which evidently the insect had broken off in its partially successful attempts to release itself.

Amber was early known by the ancients, and called *ηλεκτρον*, *electrum*, whence, on account of its electrical susceptibilities, we have derived our word *electricity*. It was called by some Lyncurium, though this name was applied, as is supposed, also to another mineral of remarkable electrical properties; also Succinum, because of its supposed vegetable origin, as stated by Pliny, "quod arboris *succum*, prisci nostri credidere."

Amber is extensively employed for ornamental purposes, and large fine specimens are highly valued. In the Royal Museum at Berlin, there is a mass weighing 18 pounds. A mass has lately been found in the kingdom of Ava, India, which is nearly as large as a child's head. It is intersected in various directions by veins of crystallized carbonate of lime, from the thickness of paper to one twentieth of an inch.

It is employed for the manufacture of a varnish, and for obtaining succinic acid, which it affords at a low temperature.

SCHEERERITE. Steatus acicularis.

Prismatic Resinous Naphthaline, *Koenlein*.

541. Occurs in loosely aggregated crystalline grains and foliæ; also in minute acicular crystals, deposited in small cavities in coal.

Soft. 0·65, Macaire Princep. *Lustre* pearly, or resinous; feebly shining. *Color* whitish. Easily frangible. Tasteless. Inodorous. *Feel* not greasy. At 111°, F., according to M. Prinsep, it melts, and in the fused state resembles a fatty oil, and like it, penetrates paper; these spots, however, may be removed by heat. On cooling, the mineral crystallizes in four sided acicular crystals. Its boiling point is at 197½° F.

It contains, according to M. Prinsep, (Pogg. Ann. xv. 294,) Carbon 73, and Hydrogen 24, nearly, which is almost equivalent to one atom of the former to two of the latter. It takes fire easily, and is completely consumed, giving out much smoke and a feebly aromatic odor.

Obs. It was found by Capt. Scheerer, in the year 1822, in a bed of brown coal, near St. Gallen, in Switzerland. These beds are from two to three feet thick, and appear to belong to a very recent formation.

Allied with this species is, probably, the substance called mineral tallow, or Hatchettine. It is described as white, and as having nearly the consistency of spermaceti, but without any traces of crystallization. It is tasteless, has a resinous or waxy lustre; fuses at 118° F. and boils at 290°. The variety Hatchettine is stated by Conybeare to melt at 170°. It has been found on the coast of Finland, near Inverary, and Oban, in the county of Argyle. It was first discovered by Conybeare in the iron stone of Merthyr Tydvil, in South Wales.

RETINITE. Bitumen fragrans.

Retinasphaltum.

542. Occurs in roundish masses.

H.=1—2·5. G.=1·135, Hatchett. *Lustre* often earthy externally, but slightly resinous in the fracture. *Color* light yellowish-brown, sometimes green, yellow, red, or striped. Subtransparent—opaque. *Fracture* conchoidal. Often flexible and elastic, when first dug up; but it loses this property on exposure.

It contains, according to Hatchett (Phil. Trans., 1804, p. 404) and Bucholz, (Schweigger's Jour. i. 293,)

Vegetable Resin	55
Bitumen	42
Earthy matter	3=100, H.

Resin soluble in alcohol	91
Resin insoluble in alcohol	9=100, B.

It takes fire in a candle, burns with a bright flame, and emits a peculiar fragrant odor. It is soluble in alcohol, excepting an unctuous residue.

Obs. This species was first observed near Devonshire by Dr. Milles, accompanying Bovey coal. It has since been met with near Helboa, in the county of Mansfield, at Wolchow, in Moravia, and near Halle, in brown coal. The purer specimens often consist of alternating layers. The variety from Bovey Tracey has a dry earthy texture, while that from Wolchow is hard and resinous.

MINERAL CAOUTCHOUC. Bitumen flexile.

543. Occurs in soft flexible masses.

G.=0·9053—1·233, the Derbyshire variety. *Lustre* resinous. *Color* blackish-brown, of various shades. Subtranslucent; sometimes presents a brilliant dark orange-red color by transmitted light. *Fracture* conchoidal.

According to M. Henry, junior, (Ann. des Mines, xii. 269,) it contains

	English variety.	
Carbon	52·25	58·26
Hydrogen	7·46	4·89
Nitrogen	0·15	0·10
Oxygen	40·11=99·97.	36·75=100.

It takes fire readily, and burns with a lively yellow flame, giving out a bituminous odor.

Obs. This species was first observed in Derbyshire, in the forsaken lead mine of Odin, by Dr. Lister, in 1673, who called it a subterranean fungus, and was uncertain whether it belonged to the vegetable or mineral kingdom. In 1816 it was accurately described by Hatchett, in the Linnæan Transactions, iv. 146. It has since been found in a coal mine at Montrelais, at the depth of 230 feet; and, according to Hausmann, (Handbuch, iii. 273,) it occurs at Neufchatel, and in the island of Zante. It has also been met with in bituminous limestone at Woodbury, Conn.

BITUMEN. Bitumen communis.

Black Mineral Resin, *M.* and *J.* Mineral Oil. Naphtha, Petroleum, Mineral Pitch. Asphaltum. Bergpech, Bergtheer, *Haus.* Asphalt, *L.* Bitume, *H.*

544. Occurs both solid and fluid, and is possessed of no regular form.

H.=0—2. G.=0·8—1·2. *Lustre* resinous. *Streak* commonly similar to the color. *Color* black, brown, and reddish; fluid varieties nearly colorless and transparent. *Fracture* of solid varieties perfectly conchoidal, and very brilliant. Sectile. Odor bituminous.

Naphtha (the fluid variety) contains, according to Thomson,

Carbon	82·2
Hydrogen	14·8=97.

Inflames readily, and burns with much smoke.

Obs. The solid varieties of this species have been termed *mineral pitch*, or *asphaltum*; the fluid, *mineral oil.* The *earthy* and *slaggy* mineral pitch are two varieties of solid bitumen; the former is distinguished from the latter by its less conchoidal fracture. *Petroleum* is a fluid bitumen, which oozes from certain rocks of the coal formation, and becomes solid on exposure. *Naphtha* is a limpid or yellowish fluid; but when exposed to the air it deepens in color, and increases in consistency, till gradually it assumes the characters and appearance of petroleum. Naphtha may again be obtained from petroleum by heat.

Ozokerite, a variety of black bitumen lately discovered by Meyer, and named by Glocker, occurs in a sandstone in Moldavia, near Slanik, in the neighborhood of coal and rock salt; also under similar circumstances near Vienna. It is found in irregular translucent masses of a large size, presenting a leek-green color by reflexion, but brown, or brownish-yellow, in small pieces, by transmitted light. It contains Carbon 85·204, and Hydrogen 13·787, or one atom of hydrogen to one of carbon, and thus resembles in composition the naphtha of Persia.

Asphaltum is met with abundantly on the shores of the Dead Sea; at the pitch lake of Trinidad, where it is much mixed with sand; in reniform stalactitic masses at Matlock, in Derbyshire; in granite, with quartz and fluor, at Poldice, in Cornwall; in cavities of Chalcedony and calc spar, in Russia, and other places. Naphtha issues from the earth in large quantities in Persia and the Birman empire. At Ragoon there are upwards of 500 naphtha wells, which afford annually 412,000 hhds.

Petroleum is met with in many parts of the United States. Kenhawa in Virginia, Scotsville, Ken., Duck Creek in Munroe Co., Ohio, Liverpool, Ohio, are among its localities. In New York it is found floating on the surface of Seneca lake, and is hence called *Genesee* or *Seneca* oil.

Naphtha affords both fuel and lights to the inhabitants of Badku, on the Caspian. It is also employed in Persia, and the Birman empire, as a lotion in cutaneous eruptions, and as an embrocation in bruises and rheumatic affections. It is employed for various purposes in the arts; particularly in the manufacture of varnish, and as a substitute for oil in the formation of oil paint, it being preferred on account of its rapid evaporation and drying.

Bitumen, in all its varieties, was well known to the ancients. It is reported to have been employed in the construction of the walls of Babylon, and at Agrigentum it was burnt in lamps, and called Sicilian oil. The Egyptians also made use of it in embalming.

ORDER II.—ANTHRACINEA.

BITUMINOUS COAL. ANTHRAX BITUMINOSUS.

Bituminous Mineral Coal, *M.* Common Coal. Brown Coal. Black Coal. Cherry Coal. Splint Coal. Cannel Coal. Jet. Lignite. Braunkohle. Pechkohle. Blätterkohle. Bituminoses Holz. Houille, Jayet, *H.*

545. Presents no regular form or structure.

H.=1—2·5. G.=1·2—1·5. *Lustre* more or less resinous. *Streak* and *Color* black, or brown; often grayish, when impure. Opaque. *Fracture* conchoidal—uneven. Brittle, or sectile.

This species comprehends several varieties.

Pitch, or *caking coal*, when heated, at first breaks into numerous small pieces, which, on raising the heat, unite in a solid mass. Its color is velvet-black, or grayish-black. Specific gravity 1·269. It takes fire readily, and burns with a lively yellow flame, but requires frequent stirring to prevent its caking, which prevents the ingress of air for combustion. The principal beds at Newcastle afford this kind of coal. It contains, according to Thomson, (abstracting the earthy matter,) Carbon 24·75, Hydrogen 1·375, Nitrogen 5·25, and Oxygen 1·5.

Cherry coal has much the appearance of caking coal, but is devoid of the property of softening and caking, when heated. It is very frangible, and hence in mining it, there is considerable waste. Near Birmingham, the loss in mining, including the pillars, amounts to two thirds of the whole. G.=1·265. It burns more rapidly than caking coal, with a clear yellow flame. The combustible part contains, according to Thomson, Carbon 25·5, Hydrogen 4·25, Nitrogen 3·5, Oxygen 1. It leaves about 10 per cent. of ashes. It occurs at the Glasgow coal beds, and received its name from its lustre and beauty.

The *splint coal* from the same region, is much harder than the cherry coal, and is hence sometimes called *hard coal*. It contains, besides 9·5 per cent. of earthy matter, Carbon 21, Hydrogen 1·75, Nitrogen 1·75, Oxygen 3·5.

Cannel coal has a dark grayish black or brownish-black color, a large conchoidal fracture, and receives a good polish. It takes fire readily, and burns without melting, with a clear yellow flame. On this account it has been used as a substitute for candles, and hence received its name. This coal contains, on an average, about 11 per cent. of earthy matter. The combustible part, according to Thomson, consists of Carbon 8·25, Hydrogen 2·75, Nitrogen 1·75. It abounds at Lesmahago, about twenty miles from Glasgow, also in different parts of Ayrshire, where it is made into inkstands, snuff-boxes, and other similar articles. *Jet* is a variety of cannel coal, but is blacker, and has a more brilliant lustre. It occurs in detached pieces in clay, on the coast near Whitby, in Yorkshire, and at Ballard Point, and elsewhere. It is the *Gagates* of Dioscorides and Pliny, a name derived from the river Gagas, in Syria, near the mouth of which it was found.

Wood coal, or *lignite*, occurs in the newest formations, and has all the structure and appearance of carbonized wood.

The Newcastle coal mines are stated to employ sixty thousand men. The principal coal mines of France are those of St. Etienne, Mons, Charleroi, and Liege. Germany is not rich in coal mines. The only deposits in Sweden occur at Höganes, near Helsinborg in Scania. Norway, Denmark, and Russia, seem to be entirely destitute of coal beds. Some trifling quantities are found in the Appennines, in Italy. In Spain, coal occurs in Andalusia, Arragon, Estremadura, Catalonia, Castile, and the Asturias, but in quantities of little importance. The only coal bed in Portugal which is worked, is situated in the province of Beira. Coal is also abundant in China and Japan, in the island of Madagascar, in Africa, and New Holland. But nowhere are its deposits more extensive and numerous than in the United States. It occurs extensively throughout the middle and western states.

ANTHRACITE. ANTHRAX LAPIDEUS.

Non-bituminous Mineral Coal, *M*. Glance Coal. Mineral Carbon. Blind Coal. Columnar Coal. Kilkenny Coal. Stangenkohle. Glanzkohle, *W*. Anthrazit, *Haus*. Kohlenblende, *L*. Anthracite, *H*.

546. It presents no regular structure.

H.=2—2·5. G.=1·3—1·6; 1·52—1·55, Pennsylvania coal; 1·75, Rhode Island coal. *Lustre* submetallic. *Streak* and *Color* iron-black, sometimes grayish-black; often beautifully iridescent. Opaque. *Fracture* conchoidal.

It consists of nearly pure carbon.

The following composition of specimens from Lehigh, Penn., and from Rhode Island, were obtained by Vanuxem, (Journal of the Acad. Nat. Sc. of Philad., v. 17:)

	Pennsylvania.	Rhode Island.	
Carbon	90·1	90·03	77·70
Water	6·6	4·90	6·70
Silica	1·2	2·14	8·50
Alumina	1·1	—	trace
Oxyd of Iron and Mang.	0·2=99·2.	2·50=99·57.	7·10=100.

It burns with very little flame, and no smoke or bituminous odor.

OBS. Anthracite occurs principally in secondary rocks; but has been occasionally observed in more ancient strata.

It occurs at Kongsberg in Norway; in the trap of the Calton Hill, Edinburgh; at Kilkenny in Ireland, and in several parts of Wales, where it is called *Welsh culm*.

Extensive deposits of anthracite occur in Luzerne Co., Penn., in the anthracite region, as it is called, of the Susquehannah. Its length is between sixty and seventy miles, and breadth five miles, and it forms a kind of basin, through which pass the Susquehannah river and Lackawanna creek. The coal occurs throughout this region, cropping out of the hills and appearing on their sides, and the beds being nearly horizontal, they are worked without much downward excavation. The layers of pure coal are sometimes twenty or twenty five feet thick, and the excavations appear like immense caverns, whose roofs are supported by enormous columns of coal, and "into which a coach and six might be driven and turned again with ease." For a particular account of these magnificent deposits, reference may be made to a valuable article on this subject, by Prof. Silliman, vol. xviii. p. 308, of the Amer. Jour. of Sc. The adjoining counties of Schuylkill and Lehigh, also abound in this variety of coal. A variety is found also at Portsmouth, Rhode Island, and at Worcester and Mansfield, Mass.

Anthracite is now very generally employed as fuel, in the eastern and northern parts of the United States.

GRAPHITE. PLUMBAGO SCRIPTORIA.

Rhomboidal Graphite, *J*. Black Lead. Plumbago. Carburet of Iron.

547. *Primary form:* a rhombohedron. *Secondary form:* flat

six sided tables, having their basal planes striated parallel to the alternate edges. *Cleavage* parallel with the base of the prism perfect. Commonly in imbedded, foliated, or granular masses.

H.=1—2. G.=2·0891. *Lustre* metallic. *Streak* black and shining. *Color* iron-black—dark steel-gray. Opaque. Sectile; soils paper. Thin laminæ flexible. *Feel* greasy.

It is composed of carbon and a variable quantity of iron, which, according to Thomson, is mechanically mixed with the carbon. The following are a few of the analyses:—

	Scheele.	Berthollet.	Vauquelin.	Saussure.		Vanuxem.
Carbon	81	90·0	92	96		94·4
Iron	10	9·1	8	4	Oxyd of Iron	1·4
Oxygen	9=100.	——=99·1	——=100.	——=100	Silica	2·6=98·4.

At a high temperature it burns without flame or smoke, and leaves a portion of red oxyd of iron. It is infusible before the blowpipe both alone and with reagents. It is also unaffected by acids.

Obs. Graphite occurs in beds and imbedded masses in granite, gneiss, mica slate, primitive limestone, and gray-wacke, and is often connected with deposits of coal. It is also met with in greenstone.

A remarkably fine variety of graphite occurs at Borrowdale in Cumberland, in nests in a greenstone rock, which constitutes a bed in clay slate. In Glenstrathfarrar, in Invernesshire, it forms nests in gneiss, and is associated with garnet. At Arendal, in Norway, it is found in quartz. At Craignan, in Ayrshire, it occurs in coal beds, and is situated in a layer of coal between two layers of greenstone. It is mixed with anthracite, and forms a bed from three to six feet thick.

Foliated masses of graphite occur near Ticonderoga on Lake George, upon Roger's Rock, associated with pyroxene and sphene. Near Amity, Orange Co., N. Y., it is met with in white limestone, accompanying spinel, Brucite, hornblende, &c.; also in Bucks Co., Penn., three miles from Attleboro, associated with tabular spar, pyroxene, and scapolite; and one and a half miles from this locality, it occurs in abundance in sienite, at Mansell's black lead mine. Compact graphite is disseminated in large masses forming veins in gneiss, at Sturbridge, Mass.; at Greenville, L. C., associated with sphene and tabular spar, in primitive limestone; at Rossie, St. Lawrence Co., N. Y., with iron ore, and in gneiss.

Graphite is extensively employed in the manufacture of pencils. For this purpose it should be perfectly pure, and also of a granular structure. In the manufacture of lead pencils, it is sawn into thin slices and inserted into grooved semicylindrical pieces of wood, which are afterwards united by glue. The powder formed in the process of sawing is mingled with sulphur and gum, and employed in the manufacture of an inferior pencil. It is also a good material for crucibles, on account of its extreme infusibility. Varieties which are too impure for pencils, are well adapted for the manufacture of these articles. It is also used in polishing cast iron grates, stoves, &c., and for diminishing friction in heavy machinery.

The name *black lead*, often applied to this species, is entirely inappropriate, as it does not contain the least particle of lead.

The name of this species, graphite, is derived from γραφω, *I write*, in allusion to its extensive use as a material for writing, arising from its property of leaving a trace on paper.

Graphite does not correctly belong to the class Hypogæa. It is, however, here appended on account of its close alliance to coal.

SUPPLEMENT.

ALUMOCALCITE.

Leonhard.

448. Massive.

G.=2·174. *Streak* and *Color* milk-white, inclining to blue. *Fracture* conchoidal; small fragments may be rubbed to powder between the fingers. Adheres strongly to the moistened lip.

According to Kersten, it contains Silica 86·6, Lime 6·25, Alumina 2·23, Water 4=99·08. It yields water in the glass tube. Exposed to heat in the platinum forceps, it becomes opaque and gray colored. With borax it forms a colorless glass, and in salt of phosphorus it is soluble with the exception of a skeleton of silica.

Obs. Occurs in the clefts of ironstone veins at Eybenstock, in the Erzgebirge. Breithaupt separated it from opal, with which it had been united, and to him we are indebted for the above description.

ANHYDROUS SCOLECITE.

Nordenskiöld, Bidrag, p. 67.

449. Occurs in crystals; but their form was not mentioned by Nordenskiöld. One cleavage distinct.

H.=6. *Lustre* vitreous. *Color* white. Translucent. *Fracture* small conchoidal.

It contains, according to Nordenskiöld, Silica 54·13, Alumina 29·23, Lime 15·46, Water 1·07=99·89. Before the blowpipe its comportment is similar to that of scolecite, except that more heat is required to fuse it into a glass with soda.

Obs. Occurs in the large masses of scapolite at Ersby, in Finland. It was taken for scapolite, till its true nature was determined by Nordenskiöld.

BEUDANTITE.

Levy, Ann. of Phil. 2d ser. XI. 196.

450. *Primary form:* an obtuse rhombohedron; R : R=92° 30′. *Secondary form:* the primary with the vertical angles truncated, fig. 13, Pl. II. *Cleavage* parallel with a.

H.=4—4·5. *Lustre* resinous. *Streak* greenish-gray. *Color* black. Translucent in thin fragments, and deep brown by transmitted light.

Wollaston detected in it only the oxyds of lead and iron.

Obs. It was found at Horhausen in the district of Nassau, on the Rhine, and named by Levy, in honor of F. S. Beudant.

BLACK COPPER.

Black Oxyd of Copper, *Th.* Copper Black, *J.* Black Copper, *P.* Kupferschwarz, *W.*

451. Disseminated, or coating other copper ores, in shining botryoidal concretions, or dull friable masses. *Color* black or brownish-black. Friable, and soils the fingers.

Before the blowpipe it is infusible. With borax it affords a greenish slag.

Obs. It occurs in most of the Cornish mines, particularly at the Carravat and Zincroft mines, accompanying copper pyrites, vitreous copper, and other ores of that some metal, and probably results from the decomposition of some of them.

BOLTONITE.

452. Occurs massive; structure coarsely granular. *Cleavage* pretty distinct in one direction; in two others oblique to the first indistinct, but indicating an oblique rhomboidal prism as the primary form.

H.=5—6. G.=2·8—2·9. *Lustre* vitreous. *Streak* white. *Color* bluish-gray, yellowish-gray, wax-yellow, yellowish-white. The darker colors turn yellow on exposure. Transparent—translucent. *Fracture* uneven.

Before the blowpipe, *per se*, it is bleached and rendered transparent, but is infusible. With borax it forms a transparent glass.

Obs. Boltonite is disseminated through the white limestone at Bolton, Mass., and has also been observed in the neighboring quarries of Boxborough and Littleton.

CHLOROPHÆITE.

***Macculloch*, Western Isles, I. 504.**

453. Massive, in small grains from the size of a radish-seed to that of a pea; sometimes hollow. Transparent, and of a pistachio-green color; soon becomes brown and black and opaque, like steatite, on exposure to the air. Brittle. *Fracture* conchoidal or earthy.

It consists principally of Silica and Iron, with a little Alumina. It undergoes scarcely any change under the blowpipe.

Obs. This substance was found by Macculloch, imbedded in basalt or amygdaloid, at Scuirmore Cliff, in the island of Rum, and in Fifeshire. It has lately been observed in a basaltic dyke, near the Coquet water in Northumberland. By some mineralogists it is considered a variety of serpentine, and by others, decomposed olivine.

DAVIDSONITE.

454. *Primary form:* an oblique rhombic prism; M : M=94°, P : M about 100°; the planes were too rough for accurate measurement. *Cleavage* parallel to M.

H.=6·5. G.=2·3629. *Color* greenish-yellow. Translucent. Brittle.

It contains Silica 66·59, Alumina 32·12, Water 1·30—100·01. Infusible, *per se*, before the blowpipe. With soda it fuses imperfectly into a white enamel. With borax it affords a transparent colorless glass, having a silica skeleton in its centre.

Obs. This species was discovered by Dr. Davidson, of Aberdeen, in the granite quarry of Rubislaw, near Aberdeen, where it constituted a detached mass in granite.

ERLAMITE.

Schweigger's Journ. of Chem. VII. 76. Erlan, *L.*

455. Massive; compact, or in small and fine granular distinct concretions. Structure distinctly crystalline, but no regular cleavage has been observed.

H.=5. G.=3—3·1. *Lustre* feebly shining or dull. *Streak* white, shining with a resinous lustre. *Color* light greenish-gray. *Fracture* sometimes foliated; often splintery.

It contains, according to Gmelin, Silica 53·16, Alumina 14·03, Lime 14·39, Soda 2·61, Magnesia 5·42, Oxyd of Iron 7·14, Oxyd of Manganese 0·64. It fuses readily in the blowpipe flame into a slightly colored transparent globule; with borax it forms a clear greenish glass.

Obs. Erlamite was discovered by Breithaupt, in the Saxon Erzgebirge, forming a part of the oldest gneiss formation. It is stated to resemble Gehlenite, but by some is considered a mechanical mixture.

FULLERS' EARTH.

456. Massive; impalpably granular.

H.=1. G.=1·81—2·5. Dull. *Color* gray, white, greenish-gray, opaque, or feebly subtranslucent. *Fracture* uneven or earthy. *Feel* soapy. Adheres very slightly to the tongue. Falls to pieces in water, and forms a paste which is not plastic.

It possesses the peculiar property of absorbing oleaginous and greasy matter, and hence is used in cleaning woollen cloth.

It probably varies much in its composition. Dr. Thomson gives the following as the constituents of one of its varieties, which had a specific gravity of 4·448: Water 24·95, Silica 44·00, Alumina 23·06, Lime 4·08, Magnesia 2, Protoxyd of Iron 2=10·009. Another mineral, from Magdalen Island, in the Gulf of St. Lawrence, has been analyzed by Dr. Thomson, (Min. i. 247,) possessing analogous properties; opaque; may be scratched by the nail; texture earthy; dull; specific gravity 2·517. Its composition was found to be as follows: Silica 47·65, Peroxyd of Iron 20·50, Alumina 17·70, Lime 2·20, Water 11·05=99·10. In England it occurs at Nutfield in Surrey, and in other places.

HUMBOLDTILITE.

457. *Primary form:* a right square prism. *Secondary form:* the primary with the lateral edges truncated or beveled.

Hard enough to scratch glass. G.=3·104. *Lustre* vitreous. *Color* brown; slightly yellowish, or greenish-yellow. Translucent, and in thin laminæ transparent. *Fracture* conchoidal.

It contains, according to Monticelli and Covelli, Silica 54·16, Lime 31·67, Magnesia 8·83, Alumina 0·50, Peroxyd of Iron 2=97·16. It fuses before the blowpipe with effervescence, but without forming a globule. With borax it fuses into a transparent glass. With salt of phosphorus or soda, it fuses with extreme difficulty into a brown opaque enamel. Pulverized, and treated with nitric acid, it gelatinizes.

Obs. It occurs at Vesuvius, in lava, and was described and named by Monticelli and Covelli.

HYDROUS ANTHOPHYLLITE.

458. Structure columnar; diverging, scopiform; fibres separable, brittle, inelastic.

H.=2·5. G.=2·911. *Lustre* silky. *Color* greenish-yellow. Opaqne. Sectile. *Feel* soft.

Thomson obtained for its constituents, Silica 54·98, Magnesia 13·376, Peroxyd of Iron 9·832, Protoxyd of Manganese 1·2, Potash 6·804, Alumina 1·560, Water 11·448 =99·200.

Obs. This mineral was received by Dr. Thomson from Dr. Torrey, of New York, and described by him as above.

KNEBELITE.

459. Massive. Surface uneven and cellular.

Hard. G.=3·71. *Lustre* glistening. *Color* gray, spotted dirty-white, red, brown, and green. Opaque. *Fracture* subconchoidal. Brittle.

It contains, according to Döbereiner, Silica 32·5, Protoxyd of Iron 32, Protoxyd of Manganese 35. It is not altered, *per se*, by the blowpipe. With borax it fuses readily into a dark-olive green pearl.

Obs. This mineral was received by Döbereiner from Major Von Knebel, after whom it is named. Its locality is unknown.

MONAZITE.

Breithaupt, pp. 239 and 330. Mengite, *Brooke*, Ann. Phil. 2d ser. x. 187.

460. *Primary form:* an oblique rhombic prism; M : M=95° 30′, P : M=100°, as measured by Brooke.

H.=6. G.=4·88—4·922. *Lustre* vitreous, weak. *Streak* reddish-white. *Color* brown, or smoky-red,

In a white heat, before the blowpipe, its edges are rounded, and the color becomes greenish-yellow. On charcoal, with carbonate of soda and borax, it fuses easily with effervescence in the reducing flame into a dark-yellow bead, which becomes of a light-yellow on cooling, and by flaming is rendered opaque. With salt of phosphorus in the oxydating flame, it fuses readily into a bead, which is yellow while hot, but on cooling becomes yellowish-green and muddy. From the above reactions it is evident that monazite contains uranium, combined with some earth.

Obs. This mineral was brought by Fiedler from the Uralian mountains. It occurs near Slatoust, associated with flesh-red feldspar, imbedded in an extensive bed of granite.

PELOKONITE.

Richter, Poggendorf's Annalen, XXI. 590.

461. Has not been observed in crystals.

H.=3. G.=2·567. *Lustre* vitreous, weak. *Streak* liver-brown. *Color* blackish-blue. Opaque. *Fracture* conchoidal.

Contains Phosphoric Acid, with the Oxyds of Iron and Manganese, and some Copper. It dissolves easily in muriatic acid, less easily in nitric acid. The muriatic acid solution has a pistachio-green color.

Obs. Occurs in Chili, associated with malachite and chrysocolla. Its name is derived from πελος, *brown*, κονις, *powder*, in allusion to the color of the streak, by which character it is distinguished from cupreous manganese.

PIMELITE.

462. Massive; earthy.

H. under 3. Dull. *Color* apple-green; yellowish. Opaque. Soft and greasy to the touch. *Fracture* earthy.

It contains, according to Klaproth, Oxyd of Nickel 15·62, Silica 35·00, Alumina 5·10, Water 37·93, Magnesia 2·25, Lime 0·40=96·30. Before the blowpipe it does not fuse, but assumes a scoriaceous appearance on the edges, and becomes dark-gray. With borax it yields a violet-colored globule, in which the nickel is reduced.

Obs. Accompanies chrysoprase at Kosenutz and Glassendorf, in Silesia, and in New Fane, Vermont.

PYROPHYLLITE.

563. Amorphous; structure radiated; an indistinct rectangular cleavage. *Lustre* pearly. *Color* white.

According to Hermann, of Moscow, (Poggendorf's Annalen, xv. 592,) it contains Silica 59·79, Alumina 29·46, Magnesia 4, Peroxyd of Iron 1·8, Water 5·62=100·67. Before the blowpipe, *per se*, it swells up and spreads out in a fan-like shape, and increases to twenty times its former bulk. The swollen mass is infusible. With carbonate of soda it melts into a clear yellow glass. With salt of phosphorus it fuses into a colorless glass, leaving a silica skeleton. Heated with nitrate of cobalt it assumes a fine blue color.

Obs. Occurs in the Uralian mountains, between Pyschminsk and Beresof. It was formerly considered a radiated talc; but is peculiar in its comportment before the blowpipe.

RAPHILITE.

564. In diverging acicular crystals. Needles or fibres easily separable.

H.=3·75. G.=2·85. *Lustre* between glassy and silky. *Color* white, with a shade of bluish-green.

It contains, according to Thomson, (Min. i. 153,) Silica 56·478, Lime 14·750, Alumina 6·160, Protoxyd of Iron 5·389, Protoxyd of Manganese 0·447, Magnesia 5·451, Potash 10·533, Moisture 0·5=99·708. Before the blowpipe it becomes opaque and white, and the extremity of the fibre is rounded off, but does not fuse into a globule. With carbonate of soda it fuses slowly, and with effervescence, into a translucent white glass. With borax it melts into a transparent colorless glass, leaving silica.

Obs. Occurs in the township of Perth, in Upper Canada. It was described and analyzed by Dr. Thomson; and also named from *ραφις, a needle*, from the structure of the mineral.

RENSSELAERITE.

***Emmons** and **Hall**, Comunication relative to a Geolog. Survey of New York, Feb., 1837.*

565. *Primary form:* an oblique rhombic prism; M : M=86° and 94°, *c. g.* P : M =106° 30′. *Cleavage* parallel with P. *Imperfect crystallizations:* structure somewhat granular; particles strongly coherent.

H.=3·5—4. G.=2·874. *Color* white, or yellowish-white; some varieties present a dark-slate color, owing to an intermixture of foreign matter. *Fracture* uneven.

Before the blowpipe it fuses with difficulty into a white enamel. With nitrate of cobalt it assumes a pale flesh-red color.

Obs. This species occurs in Canton, St. Lawrence Co., N. Y., forming irregular masses in primitive limestone. It has the unctuous feel of steatite, but is of superior hardness. In crystalline form it resembles pyroxene; but it differs from this species in its hardness and specific gravity. It was named in honor of the Hon. Stephen Van Rensselaer.

RETINALITE.

566. In amorphous masses, resembling lumps of resin.

H.=3·75. G.=2·493. *Lustre* resinous, shining. *Color* brownish-yellow. Translucent. *Fracture* splintery.

It contains, according to Dr. Thomson, (Min. i. 201,) Silica 40·55, Magnesia 18·856, Soda 18·832, Peroxyd of Iron 0·620, Alumina 0·3, Water 20=99·158.

Obs. This mineral was received by Dr. Thomson from Dr. Holmes, of Montreal; its locality is at Granville, L. C. It was considered a variety of serpentine.

SORDAWALITE.

Nordenskiöld's Bidrag, p. 86.

567. Massive; no traces of cleavage apparent.

H.=2·5—3. G.=2·53—2·58. *Lustre* vitreous. *Streak* liver-brown. *Color* grayish or bluish-black. Opaque. *Fracture* conchoidal. Brittle.

It contains, according to Nordenskiöld, Silica 49·4, Alumina 13·8, Peroxyd of Iron 18·17, Magnesia 10·67, Phosphoric Acid 2·68, Water 4·38=98·02. Before the blowpipe, alone, it is difficultly fusible into a blackish globule. With borax it forms a green glass. With a small quantity of soda it fuses into a blackish-green glass; with a larger quantity into a slag. It is partly soluble in muriatic acid. It becomes reddish on exposure to the atmosphere.

Obs. Forms thin layers on common trap, near the town of Sordawala, in Finland; at Bodenmais, in Bavaria, it is associated with magnetic pyrites. It resembles pitcoal in appearance. Nordenskiöld first described and analyzed it.

TERENITE.

***Emmons*, Communication relative to a Geolog. Survey of New York, 1837.**

568. *Cleavage* parallel to the sides and diagonals of a right square prism.

H.=2. G.=2·53. *Lustre* faint, pearly. *Color* yellowish-white, or pale yellowish-green. Fragile.

In the exterior flame of the blowpipe it is immediately converted into a white enamel; in the interior it fuses with ebullition into a porous glass. With nitrate of cobalt the enamel assumes a lively blue color.

Obs. It occurs in a vein about an inch wide, traversing granular carbonate of lime, in Antwerp, St. Lawrence Co., N. Y. Its name alludes to its characteristic fragility, and is derived from the Greek *τερην*, *tender*.

TRIPOLI.

569. A mechanical mixture of sand and clay; according to Bucholz and Haase, it contains

Silica	81·0	90
Alumina	1·5	7
Oxyd of Iron	8·0	3
Sulphuric Acid	3·5	—
Water	5·0=99, B.	—=100, H.

It occurs massive, of a yellowish-gray *color*, a meagre, and somewhat rough *feel*, but does not adhere to the tongue. It imbibes water, by which it is softened. When burnt, it becomes quite hard. It occurs near Prague, in Bohemia; in diluvial beds at Auberg, in Bavaria, and many other places. It is used in polishing metallic surfaces, and occasionally in making forms for casting.

WEBSTERITE.

Aluminite. Hallite. Trisulphate of Alumina, *Thom*.

570. Reniform, massive; impalpable.

H.=1·5—2. Yields to the nail. G.=1·6606. *Lustre* dull, earthy. *Streak* white, a little glimmering. *Color* white. Opaque. *Fracture* earthy. Adheres to the tongue, and is meagre to the touch.

It contains, according to Stromeyer, (Untersuchungen, p. 99,)

Sulphuric Acid	23·370	23·365
Alumina	29·868	30·262
Water	46·762=100.	46·327=99·954.

It fuses with difficulty. It is easily soluble in acids without effervescence. It absorbs water, but does not fall to pieces.

Obs. It occurs at Newhaven in Sussex, in reniform and botryoidal connections, imbedded in ferruginous clay, which rests on the chalk strata; also in similar circumstances at Epernay, in France, and in plastic clay at Hallé, on the Saale, in Prussia.

WEISSITE.

Wachtmeister, Kong. Vet. Acad. Handl., 1827, p. 80.

571. Reniform, mostly without a regular structure; the smaller pieces are sometimes foliated.

Scratches glass, but is scratched by steel. G.=2·808. *Lustre* between pearly and waxy. *Color* ash-gray, slightly brownish. Scarcely translucent.

It contains, according to Wachtmeister, Silica 59·69, Alumina 21·70, Magnesia 8·99, Protoxyd of Iron 1·43, Protoxyd of Manganese 0·63, Potash 4·10, Soda 0·68, Oxyd of Zinc 0·3, Water, with a little Ammonia 3·20=100·72. Before the blowpipe it becomes pure white, and fuses on the edges. With borax it fuses slowly into a colorless glass.

Obs. This species occurs in Erik Matt's Mine, at Fahlun, thinly scattered in a chlorite slate, in reniform masses, about the size of a hazelnut.

WOLCHONSKOITE.

572. Amorphous. *Streak* bluish-green and shining. *Color* bluish-green, passing into grass-green. Dull—shining. *Feel* resinous. Polished by the nail. *Fracture* subconchoidal. Adheres slightly to the tongue. Exceedingly fragile.

It contains, according to Berthier, (Mem. ii. 263,) Green Oxyd of Chromium 34, Peroxyd of Iron 7·2, Magnesia 7·2, Silica 27·2, Water 23·2=98·8. In water it falls to pieces; after being dried again, it is not affected by moisture. When calcined in a platinum crucible, it loses 32 per cent. of its weight, and assumes a brown color, like that of burnt coffee. It gelatinizes with hot and concentrated muriatic acid, in which one half the chromium is dissolved, the rest remaining in union with the silica.

Obs. This species occurs on Mount Jessmictski, in the Ochanskyan circle, in the Perm government of Siberia; it was discovered and named by Kammerer. It is so extremely fragile as to fall to pieces with the slightest blow.

ZEUXITE.

***Thomson*, Mineralogy, I. 320.**

573. In small rectangular prismatic crystals, promiscuously arranged; loosely coherent.

H.=4·25. G=3·051. *Lustre* vitreous, glistening. *Color* brown, with a slight shade of green, when viewed in mass. Opaque.

It contains, according to Thomson, Silica 33·48, Alumina 31·848, Protoxyd of Iron 62·01, Lime 2·456, Water 5·28=99·074. Before the blowpipe, in a glass tube, it gives out water, and emits an odor which may be termed bituminous. Color deepened by the blowpipe, and the edges of the crystals rendered of a scoriaceous appearance. With carbonate of soda it forms readily an opaque bottle-green glass. With borax it effervesces, and forms a very dark brown glass.

Obs. It occurs in the Huel Unity Mine, three miles east of Redruth, in Cornwall, and is hence named by Dr. Thomson from *ζευξις*, *union*.

ZURLITE.

Monticelli, **Mineralogia Vesuviana, 392.**

574. Occurs in lengthened rectangular four sided prisms, occasionally with their lateral edges replaced. *Cleavage* indistinct. Surface of the crystals rough; often with a white coating.

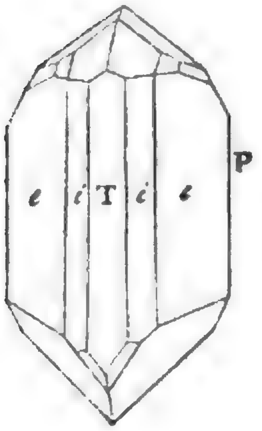
H. about 6. G.=3·27. *Lustre* resinous. *Color* asparagus-green, inclining to gray. Opaque. *Fracture* conchoidal.

Soluble in nitric acid, partly with effervescence, forming a yellow solution. Infusible, *per se*, before the blowpipe. With borax it forms a black glass.

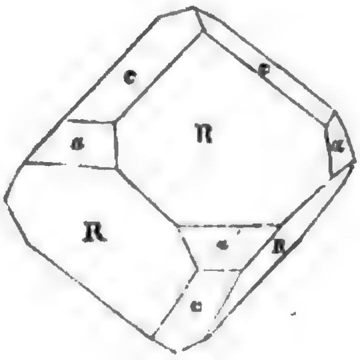
Obs. The only known locality is Vesuvius, where it occurs generally in large distinct crystals, and is associated with calc spar, &c. It was discovered in 1810, by Ramondini. Its name was proposed in compliment to the Neapolitan minister, Sig. Zurlo.

The following are additional figures of the species Euclase, Chabazite, and Brittle Silver Ore:

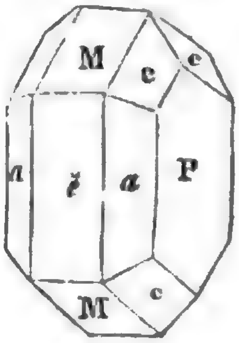
Euclase.
p. 325.



Chabazite.
p. 282.



Brittle Silver Ore.
p 417.



APPENDIX A.

MATHEMATICAL CRYSTALLOGRAPHY.

THE following concise treatise on Mathematical Crystallography is an abstract of a very extended and elaborate work on this subject, in the German language, by Dr. C. F. Naumann.* Occasional explanations have been added, and also some generalizations of facts which have reduced the space it would otherwise occupy.

The methods of calculation introduced by the *Abbé Haüy* were founded chiefly on the principles of plane trigonometry. His system was, therefore, mostly destitute of general formulas applicable to every variety of solid. The application of the principles of Analytical Geometry, affords a much simpler, and at the same time a more general method of calculation. This application was first made by a German mineralogist, Chr. Samuel Weiss, whose principles were similar to those which have been adopted by Naumann.

Guided by the principles to be developed, our knowledge of the angles of crystals may, in most instances, be based on the sure principles of mathematics, instead of separate measurements, which from the want of smoothness or lustre in the surface, are more often quite doubtful than correct. The determination of a single angle in a diametric or tetraxonal solid is, in some instances, sufficient for ascertaining every angle, interfacial or plane, that the solid contains; and in the monometric solids not even this datum is required.

A knowledge of analytical geometry being a necessary preliminary to a full understanding of this subject, it will be first considered.

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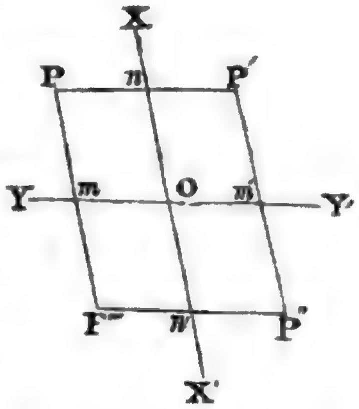
* Lehrbuch der reinen und angewandten Krystallographie, von Dr. Carl Friederich Naumann; in zwei Banden, 8°, mit 39 Kupfertafeln. Leipzig, 1830.

ANALYTICAL GEOMETRY.

CHAPTER I.

THE SITUATION OF A POINT AND LINE IN A PLANE.



1. P being the given point, draw from it, to YO and XO, and parallel to the same, the lines Pm and Pn. As there can be but one Pm and one Pn, thus drawn from the point P, the position of this point is evidently determined when Pm and Pn are known, XO and YO being supposed to be given in position. So also any point is similarly determined when in like manner, its situation, relative to two lines given in position, is known.

The two different kinds of lines which have here been used, in the determination of a point, and which are of like importance in all calculations on this subject, have received peculiar names. XO and YO, or as extended, XX' and YY', are termed *axes*, as they are the fixed lines to which all other lines are referred. Pm and Pn are called the *coördinates* of the point P; those parallel to one axis, XX', are designated by the letter x, and those parallel to YY', by the letter y. In like manner the axis XX' is termed the axis of x, the coördinates x being in that direction; and for a like reason, the axis YY' is denominated the axis of y. The axes bisect each other in the point O, which is termed the *centre* or *origin*. If the point P were moved towards m, the line Pm would decrease, and finally would become equal to 0; and then, if continued, would increase on the opposite side of the axis. If, therefore, the sign + is applied to Pm, the sign — should be applied to $P'''m$; and so generally, if lines above YY' are +, those below will be —: so also, if lines to the right of XX' are — those to the left will be +. It follows, hence, that nO, or the distance of any point, as n, in the axis of x, from O, may equal $\pm a$; and $mO = \pm b$, designating nO and mO, by a and b; that is, the point n may be at equal distances either above or below the origin and the point m, either to the right or left of it.

Likewise the coördinates of P in each of the quadrants will be as follows:

in XY, $+Pn, +Pm$. in XY', $-Pn, +Pm$.
in $X'Y'$, $-Pn, -Pm$. in $X'Y$, $+Pn, -Pm$.

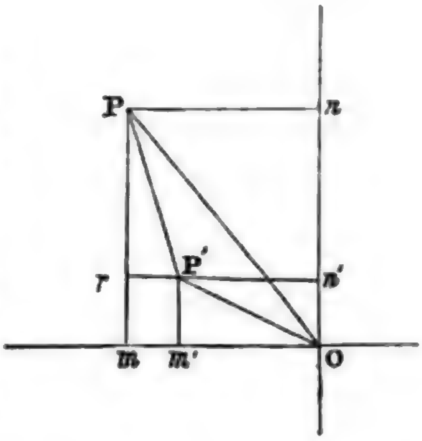
The inclination of the axes may be either rectangular or oblique, and in the one case the system of axes is termed the *Rectangular*, or *Orthometric System*, and in the other, the *Oblique*, or *Clinometric System*.

I. RECTANGULAR SYSTEM OF AXES.

2. *The distance of a point from the origin.* P being the given point, its distance from O, the origin, is $PO=\sqrt{Pm^2+mO^2}$. (Euc. I. 47.)

But $Pm=x$, and $mO=Pn=y$.

$$\therefore PO=\sqrt{x^2+y^2}=D.$$



By substituting the values of x and y, observing the sines, which will vary with the quadrant in which the point is situated, the required value of PO is readily obtained.

If $x=0$, that is, if the line $Pm=0$, Pm and mO coincide, and the point is in the axis of y; and again, if $y=0$, the point is in the axis of x; and finally, if $x=0$ and $y=0$, the point is the origin itself.

3. *The distance of two points.* PP', the distance of the two points P and P', is equal to $\sqrt{Pr^2+P'r^2}$.

But $Pr=Pm-rm=Pm-P'm'=x-x'$;

Also, $P'r=rn'-P'n'=Pn'-P'n'=y-y'$.

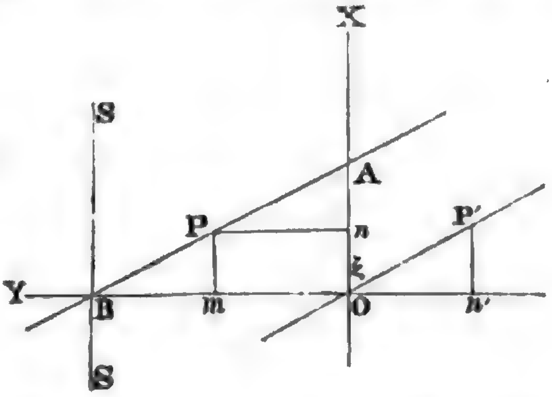
Hence, substituting these values of Pr and $P'r$ the equation for the distance of two points is,

$$R=\sqrt{(x-x')^2+(y-y')^2}.$$

The value of R, in any given instance, is obtained by substituting the values of x, x', y, and y', in this equation.

4. *Equation of a straight line.* The straight line may either cut both axes, or it may intersect but one, and consequently be parallel to the other, or it may pass through the origin.

a. Suppose it to intersect both axes, as AB. The parts of the axes cut off by the line, that is, $AO(=a)$ and $BO(=b)$ are termed the *parameter* of the line. To obtain the equation of this line, that is, an equation that will apply to any part of it, any point in the line may be assumed, and its coördinates compared with the parameters of the line. Assuming P as the point, its coördinates will be Pm and Pn, the relation of which to a and b, the parameter, may be obtained by means of the similar triangles PmB and AOB.



$$Bm : BO :: Pm : AO.$$

But $Bm = BO - mO = b - y$, and $Pm = x$, $AO = a$; consequently

$$b - y : b :: x : a, \quad \text{or,}$$

$$\frac{x}{a} = \frac{b-y}{b} = \frac{b}{b} - \frac{y}{b} = 1 - \frac{y}{b}.$$

$$\therefore \frac{x}{a} + \frac{y}{b} = 1,$$

which is the desired equation, since by varying the values of x and y, it may be made to apply to any point in the line. By changing the sines, it may become the equation of a similar line in either of the quadrants.

b. If the line is parallel to one axis, the parameter in the direction of that axis will become infinite, that is, if the line, as $S\,S$, is parallel to the axis of x, $a = \infty$, hence $\frac{x}{a} = 0$, and consequently the equation becomes $\frac{y}{b} = 1$, or $y = b$, which is identical with the equation of the point b, in which the line $S\,S$ intersects the axis of y. If $b = \infty$, in the same manner $x = a$.

c. If the line is removed to the origin, and parallel to its former position, we find, from the similarity of the triangles, ABO and $P'On'$, $P'n' : AO :: n'O : BO$. But $P'n' = x$, and $n'O = -y$, it being to the right of XO. Therefore, $x : a :: -y : b$, or,

$$\frac{x}{a} = -\frac{y}{b}; \quad \text{hence, finally,} \quad \frac{x}{a} + \frac{y}{b} = 0.$$

An equation differing from that of the straight line in this merely, that the right hand quantity is 0 instead of 1.

If $\xi =$ the angle which the line makes with the axis of x, we obtain from the triangle $OP'n'$, in which the angle $OP'n' = \xi$, $On' = P'n' \tan. \xi$, or substituting x and y for On' and $P'n'$, $y = x \tan. \xi$. But $\tan. = \frac{\sin.}{\cos.}$; therefore, $y = x \frac{\sin. \xi}{\cos. \xi}$, and consequently,

$$\frac{x}{\cos. \xi} - \frac{y}{\sin. \xi} = 0.$$

It will hence be seen that in the equation of a line passing through the origin, the relative values merely of a and b are understood.

5. *Point of intersection and mutual inclination of two lines.* Let $\frac{x}{a} + \frac{y}{b} = 1$, and $\frac{x'}{a'} + \frac{y'}{b'} = 1$, be the equations of the two

lines. Since the coördinates of the two lines are identical, at the point of their intersection, the values of x, as obtained by a reduction of the two equations, will be equal ; so also with y. We may hence thus obtain the values of x and y at that point.

From the first equation $x = a - \frac{ay}{b}$. From the second $x' = a' - \frac{a'y'}{b'}$. But since x and x', as just stated, are equal at their intersection,

$$a - \frac{ay}{b} = a' - \frac{a'y}{b'}.$$

Clearing of fractions and transposing, $bb'(a - a') = b'ay - ba'y$, and dividing by $b'a - ba'$, the value of y is obtained equal to

$$\frac{bb'(a - a')}{b'a - ba'}.$$

In the same manner, we find

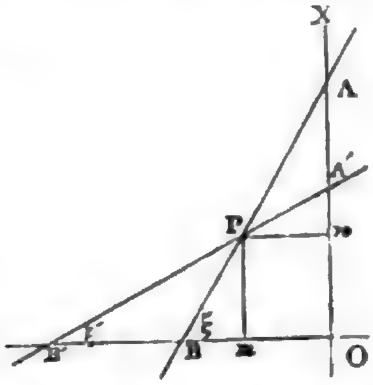
$$x = \frac{aa'(b - b')}{ba' - b'a},$$

which are the sought values of the coördinates of the point of intersection of two lines.

If ξ and ξ' equal the inclinations of the two lines to one of the axes, (the angles ABO and $A'B'O$) the desired angle, BPA', will equal the supplement of $\xi - \xi'$ $(ABO - A'B'O,)$ and therefore calling the angle ω,

$$\tan. \omega = \tan. (\xi - \xi').$$

To obtain the value of ω, we may suppose the lines to pass through the origin, where, as their position remains parallel to their former one, they will still have the same mutual inclination. The equations of the lines including the required angle, are now, (§ 4),



$$\frac{x}{a} + \frac{y}{b} = 0, \quad \text{and} \quad \frac{x'}{a'} + \frac{y'}{b'} = 0,$$

and consequently, from the two equations, we obtain, $y = -\frac{bx}{a}$, and $y' = -\frac{b'x'}{a'}$. But, (§ 4) $\tan. \xi = \frac{y}{x}$; therefore substituting the value of tan. ξ in the equation

$$\tan. (\xi - \xi') = \frac{\tan. \xi - \tan. \xi'}{1 + \tan. \xi . \tan. \xi'}, \text{ (Plane Trig.)}$$

we obtain,

$$\tan. (\xi - \xi') = \tan. \omega = \frac{-\frac{b}{a} + \frac{b'}{a'}}{1 + \frac{bb'}{aa'}} = \frac{ab' - a'b}{aa' + bb'},$$

which is the desired equation for the intersection of two lines. If the two lines are parallel, they will cut the axes proportionally, in which case $a : b :: a' : b'$, or, $ab' - a'b$, the numerator of the above fraction, $= 0$. If they are at right angles, from similar triangles, $a : b :: b' : -a'$, and consequently, $aa' + bb' = 0$, or since the tangent of 90° is infinite, the value of the fraction must be infinite, which is only the case when $aa' + bb'$, the denominator, $= 0$.

6. *The Normal from the origin of a given line.* This normal is a perpendicular to the given line, drawn from the origin. The equation of the given line is, $\frac{x}{a} + \frac{y}{b} = 1$; that of the normal, a line through the origin, (§ 4, c) $\frac{x}{\alpha} + \frac{y}{\beta} = 0$. But the normal being perpendicular to the other line, (§ 5.) $a\,\alpha + b\,\beta = 0$, and therefore $\alpha : \beta :: -b : a$. Consequently, $-b$ and a may be substituted for α and β, in the equation of the normal, for the relative value only of these quantities affects the value of the equation, (§ 4, c,) and we have for the equation of the normal,

$$\frac{x}{b} - \frac{y}{a} = 0.$$

To obtain the length of the normal, the coördinates of its point of intersection with the line of which it is the normal, are required, since the length $= \sqrt{x^2+y^2}$, (§ 2) x and y being the coördinates of that point. These coördinates may be obtained from the equations of the two lines, $\frac{x}{b} - \frac{y}{a} = 0$, and $\frac{x}{a} + \frac{y}{b} = 1$, as was done in § 5. $x = \frac{by}{a}$, and $x = a - \frac{ay}{b}$, $\therefore a - \frac{ay}{b} = \frac{by}{a}$, which reduced, gives,

$$y = \frac{a^2 b}{b^2 + a^2}. \qquad \text{So also,} \quad x = \frac{b^2 a}{b^2 + a^2}.$$

Substituting these values of x and y, in the equation $D = \sqrt{x^2+y^2}$, we obtain,

$$N = \sqrt{\frac{b^4a^2 + a^4b^2}{b^4 + 2b^2a^2 + a^4}},$$

which divided by $\sqrt{b^2+a^2}$, gives,

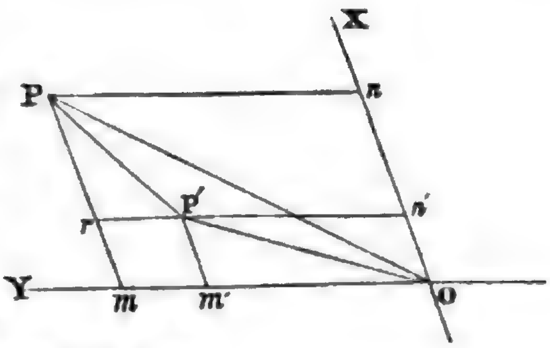
$$N = \frac{a\,b}{\sqrt{b^2+a^2}}.$$

II. OBLIQUE OR CLINOMETRIC SYSTEM OF AXES.

7. *The distance of a point from the origin, and of two points from one another.* The angle of inclination of the two axes may

be designated by ρ ($=XOY$). Let P be the point, whose distance (PO) from the origin is required. In the triangle PmO the angle $PmO=180^\circ-\rho$, $Pm=x$, and $mO=Pn=y$. Consequently,

$$PO=D=\sqrt{x^2+y^2+2xy\cos.\rho}.$$



To obtain the distance PP' of two points, we have from the triangle $PP'r$,

$$PP'=\sqrt{Pr^2+P'r^2+2\,Pr\times P'r\times\cos.\,PrP'}.$$

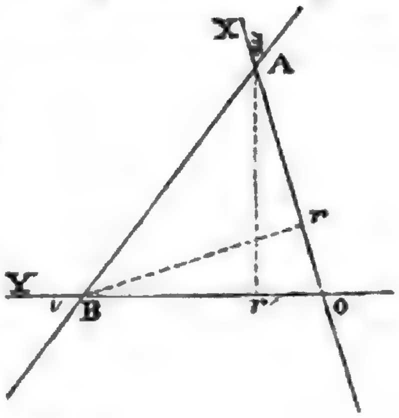
But $Pr=Pm-rm=Pm-P'm'=x-x'$. So also $P'r=y-y'$; also the angle $PrP'=PmO=180^\circ-\rho$.

$$\therefore\ R=PP'=\sqrt{(x-x')^2+(y-y')^2+2(x-x')(y-y')\cos.\rho}.$$

8. In the same manner as in the Rectangular System, (§ 4,) it may be shown, that the equation of a line is $\frac{x}{a}+\frac{y}{b}=1$, the demonstration being the same, whatever be the inclination of the axes. Similarly, also, we may obtain, for a line through the origin, the equation $\frac{x}{a}+\frac{y}{b}=0$.

9. *a. Inclination of a line to the axes.* AB is here the given line; its angles BAO and ABO, or ξ and υ, are required. Having divided the triangle ABO into right angled triangles, by the perpendicular Ar', and also again by Br, we have from the triangle ABr $\tan.\xi=\frac{Br}{Ar}$, also from the triangle BAr', $\tan.\upsilon=\frac{Ar'}{Br'}$.

But $Br=BO\times\sin.\rho=b\times\sin.\rho$,
$Ar'=AO\times\sin.\rho=a\times\sin.\rho$,
$Ar=AO-BO\cos.\rho=a-b\cos.\rho$,
$Br'=BO-AO\cos.\rho=b-a\cos.\rho$.



Therefore, $\tan.\xi=\frac{Br}{Ar}=\frac{b\sin.\rho}{b-a\cos.\rho}$, and $\tan.\upsilon=\frac{Ar'}{Br'}=\frac{a\sin.\rho}{b-a\cos.\rho}$.

b. Mutual inclination of two lines. It must be first observed, that ω, the angle of inclination equals, (as in § 5) $\xi-\xi'$, or $\upsilon-\upsilon'$. Substituting, therefore, the values of the tangents of υ and υ', in the trigonometrical formula,

$$\tan.(\upsilon-\upsilon')=\frac{\tan.\upsilon-\tan.\upsilon'}{1+\tan.\upsilon-\tan.\upsilon'},$$

and reducing, we obtain,

$$\tan.\,\omega = \frac{(ab'-a'b)\,.\sin.\,\rho}{a'(a-b\cos.\,\rho)+b'(b-a\cos.\,\rho)}.$$

When the lines are parallel, $a\,b'-a'\,b=0$, as in § 5; and when they are at right angles with one another, the denominator

$$a'(a-b\cos.\,\varrho)+b'(b-a\cos.\,\varrho)=0.$$

This equation is reduced to that for rectangular axes, by making $\varrho=90^\circ$.

10. *Normal of a given line.* The equation of the line is $\frac{x}{a}+\frac{y}{b}=1$; that of the normal, (§ 4, c) $\frac{x}{\alpha}+\frac{y}{\beta}=0$. As the inclination of the normal to the given line is 90°,

$$\alpha\,(a-b\cos.\,\varrho)+\beta\,(b-a\cos.\,\varrho)=0. \quad (§\,9,)$$

whence, $\alpha:\beta::b-a\cos.\,\varrho:-(a-b\cos.\,\varrho)$.

Consequently, substituting these relative values of a' and b' in the equation of the normal, it becomes

$$\frac{x}{b-a\cos.\,\rho}-\frac{y}{a-b\cos.\,\rho}=0.$$

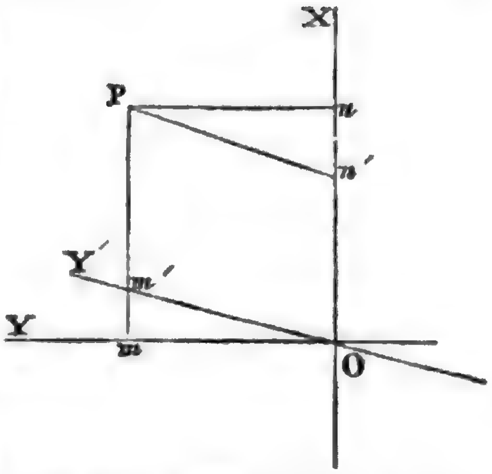
The coördinates of the point of intersection of the normal with the line may be obtained, as in § 6, or by substituting successively the values of x and y, as deduced from the equation of the normal, in the equation of the line. We thus find,

$$x=\frac{a\,b\,(b-a\cos.\,\rho)}{a^2+b^2-2\,a\,b\cos.\,\rho}, \qquad y=\frac{a\,b\,(a-b\cos.\,\rho)}{a^2+b^2-2\,a\,b\cos.\,\rho}.$$

III. TRANSFORMATION OF COÖRDINATES.

11. It is often found convenient to transform the coördinates of a point or line from one system to the other; that is, to refer a point or line to rectangular axes whose equation is given with reference to oblique axes, and also the contrary. The two new axes may have different situations relative to the others; but that case only will here be considered in which one of the axes, (x,) is the same in each, the other including an angle, with x, which may be represented by ϱ.

The point P, referred to the rectangular axes XO and YO, has the coördinates Pm and Pn ($= x$ and y.) The same point referred to the oblique axes XO and $Y'O$, has the coördinates Pm' and Pn' ($= x_{,}$ and $y_{,}$.) The relation of Pm and Pn to Pm' and Pn', is required.



$$Om = y = Om'\,(y_{,}) \times \sin. Om'm$$
$$(\sin. m'On = \sin. \rho) = y_{,} \sin. \rho.$$

So also,

$$On = x = On' + n'n = x_{,} + y_{,} \cos. \rho.$$

Substituting these values of x and y in an orthometric equation, transforms it into a clinometric equation. Again, if x and y equal the coördinates in a clinometric equation, and $x_{,}$ and $y_{,}$ in an orthometric,

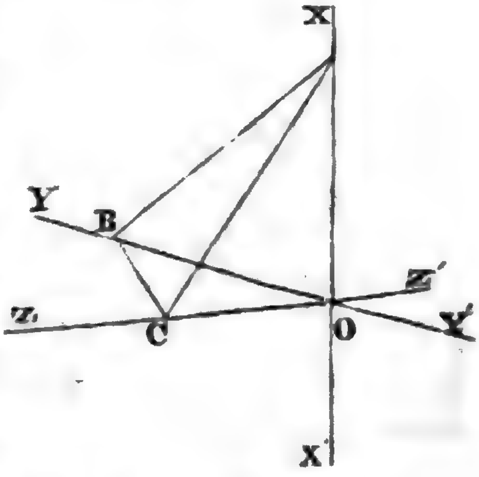
$$x = Pm - m'm = x_{,} - y_{,} \frac{\cos. \rho}{\sin. \rho}. \qquad y = Pn' = y_{,} \frac{1}{\sin. \rho},$$

and therefore by the substitution of these values of x and y, in a clinometric equation, it becomes an orthometric equation.

CHAPTER II.

THE SITUATION OF A POINT, LINE, AND PLANE, IN SPACE.

12. In calculations connected with the relations of points, lines, or planes in *space*, another axis is necessary, in addition to those employed in the former section, where the line or point was in the same plane with the axis. The new axis may be called the axis of z.



The three planes, XOY, XOZ, and YOZ, in whose intersections the axes are situated, are called coördinate planes; the first the coördinate plane of xy, the second of xz, and the third of yz. These planes intersecting one another, divide the space about a point into 8 parts. The signs + and — will be used in the same manner as heretofore, with the extension that an additional plane requires. Thus, if lines above the plane yz are +, those below will be —; so also if those to the left of xz are +, those to the right will be —;

and if those in front of xy are $+$, those on the opposite side will be $-$.

The axes may either be oblique in their mutual inclinations, or rectangular.

1. RECTANGULAR SYSTEM OF AXES.

13. *Distance of a point from the origin, and of two points from one another.* Lines drawn from the given point parallel to the axis, will be the coördinates of the point, and will be designated x, y, or z, according to the axis to which each is parallel. The signs $+$ and $-$ will be applied as stated in the last paragraph, according to the octant in which the point may be situated, so that we may have $x = \pm a$ for a point in the axis of x; and so also $y = \pm b$, $z = \pm c$. For the same reason that the diagonal of a cube is equal to the square root of the sum of the squares of three of its edges, (for x, y, and z may be considered the edges of a parallelopiped, of which the required line is the diagonal.)

$$D, \text{(required distance,)} = \sqrt{x^2 + y^2 + z^2};$$

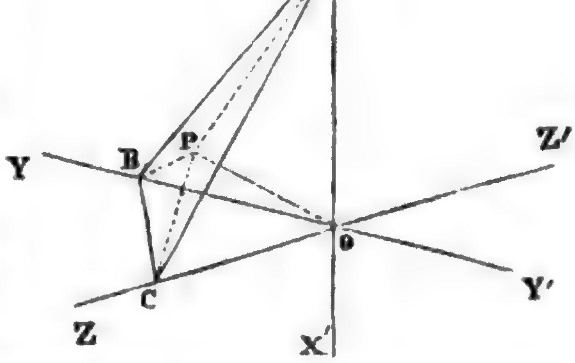
and for a similar reason we have for the distance of two points,

$$R = \sqrt{(x-x')^2 + (y-y')^2 + (z-z')^2}.$$

14. *Equation of a plane.* A plane may either intersect all three axes, or it may be parallel to one axis, or again to two, or finally it may pass through the origin.

a. If a plane intersects the three axes, it cuts off parts from each, as AO, BO, CO, ($= a, b, c$,) which are termed the parameter of the plane, situated (if the signs are all $+$) in the positive octant.

By varying the signs they may express the parameter of a plane in either of the octants. To obtain the equation of a plane, the relation between these lines and the coördinates of a point in the plane, is required. This may be obtained by dividing the pyramid $ACBO$ into three three sided pyramids, by planes passing from any point, as P in the plane ACB, through each of the axes, and making an equation between the solid contents of the three pyramids, and the pyramid $ACBO$ which they compose. The three pyramids formed by the planes through P and the axes, are $PABO$, $PBCO$, and $PCAO$; the *base* of each is a right angled triangle; in one of the coördinate planes, the *apex* is P, and conse-



quently the *height* equals one of the coördinates of P. In $PBCO$ the area of the base $BCO = \frac{1}{2}\, BO \times OC = \frac{1}{2}\, b.c$; its height equals the coördinate x of P, since this one of the coördinates is parallel to AO, the axis of x. Its solid contents therefore equal $\frac{1}{2}\, b\, c \times \frac{1}{3}\, x = \frac{1}{6}\, b\, c\, x$. In the same manner it may be shown, that $PABO = \frac{1}{6}\, abz$ and $PCAO = \frac{1}{6}\, acy$. Also the solid contents of $ABCO = \frac{1}{2}\, bc \times \frac{1}{3}\, a = \frac{1}{6}\, abc$. But as the sum of the parts must equal the whole,

$$\tfrac{1}{6}\, bcx + \tfrac{1}{6}\, acy + \tfrac{1}{6}\, abz = \tfrac{1}{6}\, abc, \text{ or dividing by } \tfrac{1}{6}\, abc,$$

$$\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 1,$$

which is the desired equation of the plane in the positive octant.

b. *If a plane is parallel to one axis*, the parameter of that axis will be infinite; that is, if the plane be parallel to x, it cannot intersect it, and consequently $a = \infty$; if it is parallel to y, $b = \infty$, if to z, $c = \infty$. But $\frac{x}{\infty} = 0$, and consequently by expunging this term from the above equation of the plane, we have

$$\frac{y}{b} + \frac{z}{c} = 1, \quad \text{or if} \quad b = \infty,\ \frac{x}{a} + \frac{z}{c} = 1, \quad \text{if} \quad c = \infty,\ \frac{x}{a} + \frac{y}{b} = 1,$$

which are the required equations. It will be observed, however, that these are also the equations of a straight line, which straight line is the intersection of the given plane with one of the coördinate planes.

c. *If the plane is parallel to two axes*, the parameters of these axes will equal ∞. If b and $c = \infty$, the equation becomes $\frac{x}{a} = 1$, or $x = a$, which is also the equation of the point in which the axis of x meets the plane; this plane will be parallel to the coördinate plane xy.

d. *When the plane passes through the origin*, its intersections with the coördinate planes will also pass through the same point, and consequently the equations of these intersections (§ 4, *c*) will be,

$$\frac{x}{a} + \frac{y}{b} = 0, \quad \frac{z}{c} + \frac{x}{a} = 0, \quad \frac{y}{b} + \frac{z}{c} = 0.$$

But from what has been stated, it is evident that these equations can proceed only from the general equation,

$$\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 0,$$

which is therefore the equation of a plane passing through the origin. This might be demonstrated, but it appears to be unnecessary. It will be remembered, that the values of a, b, and c, in this instance, as in § 4, *c*, are merely relative.

15. *Equation of the line of intersection of two planes.* Let the equations of the two planes be

$$\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1, \quad \text{and} \quad \frac{x}{a'}+\frac{y}{b'}+\frac{z}{c'}=1,$$

the equation of their line of intersection is required. Since in this line the values of the corresponding coördinates of both planes are equal, we may find the values of x, y, and z, in each of the equations, and equate them as follows:

$$x=a-\frac{ay}{b}-\frac{az}{c}, \quad x'=a'-\frac{a'y}{b'}-\frac{a'z}{c}.$$

$$\therefore\ a-\frac{ay}{b}-\frac{az}{c}=a'-\frac{a'y}{b'}-\frac{a'z}{c'}.$$

Transposing and reducing,

$$\left(\frac{a}{b}-\frac{a'}{b'}\right)y+\left(\frac{a}{c}-\frac{a'}{c'}\right)z=a-a'.$$

In the same manner is obtained,

$$\left(\frac{b}{a}-\frac{b'}{a'}\right)x+\left(\frac{b}{c}-\frac{b'}{c'}\right)z=b-b',$$

$$\left(\frac{c}{a}-\frac{c'}{a'}\right)x+\left(\frac{c}{b}-\frac{c'}{b'}\right)y=c-c'.$$

Either of these equations is deducible from the other two. To prove this, we may first reduce the coëfficients to a common denominator:

$$\left(\frac{ab'-a'b}{bb'}\right)y+\left(\frac{ac'-a'c}{cc'}\right)z=a-a',$$

$$\left(\frac{a'b-ab'}{aa'}\right)x+\left(\frac{bc'-b'c}{cc'}\right)z=b-b',$$

$$\left(\frac{a'c-ac'}{aa'}\right)x+\left(\frac{b'c-bc'}{bb'}\right)y=c-c'.$$

Making now the following substitutions:

$$ab'-a'b=\gamma, \quad bc'-b'c=\alpha, \quad ca'-c'a=\beta,$$
$$a-a'=A, \quad b-b'=B, \quad c-c'=C,$$

the equations become,

$$(1.)\ \frac{\gamma}{bb'}y-\frac{\beta}{cc'}z=A.$$

$$(2.)\ \frac{\alpha}{cc'}z-\frac{\gamma}{aa'}x=B.$$

$$(3.)\ \frac{\beta}{aa'}x-\frac{\alpha}{bb'}y=C.$$

Obtaining now two values of x, from two of these equations, and equating we have

$$\frac{\alpha aa'}{\gamma cc'}z-\frac{Baa'}{\gamma}=\frac{\alpha aa'}{\beta bb'}y+\frac{Caa'}{\beta},$$

which equation reduced gives

$$\frac{\alpha\beta}{cc'}z-\frac{\alpha\gamma}{bb'}y=B\beta+C\gamma.$$

But by actual multiplication it will be found that

$$B\beta + C\gamma = - A\alpha.$$

Hence substituting $A\alpha$, and dividing by α, we obtain the equation

$\frac{\gamma}{bb'} y - \frac{\beta}{cc'} z = A$, which is identical with Equation 1.

In the same manner any other of the three equations may be derived from the remaining two. From this fact it is a necessary deduction, that a line in space is determined by two of its equations.

16. *A line determined by two of its projections.* If the eye is placed directly over a line situated in either of the octants formed by rectangular coördinate planes, it will appear to be projected on the coördinate plane below. Its apparent situation on that plane is called the projection of the line; and the plane which passes through the line and its projection, is termed the projecting plane of the line. This plane is parallel to one of the axes, as follows from the position of the eye above given. The same line may be similarly projected on another coördinate plane, and hence, since it exists simultaneously in two projecting planes, it must be situated in the line of their intersection, and consequently may be determined by the equation of these projecting planes. But these equations are identical with those of the intersections of the projecting planes with the coördinate planes, (§ 14, *b*,) which are also the projections of the line. Consequently, it is apparent that a line may be determined by two of its projections. This also results from the conclusion of § 15. A line in space will hereafter, therefore, be represented by the equations

$$\frac{x}{\alpha} + \frac{y}{\beta} = 1, \quad \frac{z}{\gamma} + \frac{x}{\delta} = 1, \quad \frac{y}{\epsilon} + \frac{z}{\zeta} = 1,$$

α, β, &c. representing the parameters of the projections.

If the line passes through the origin, so will also its projections, and consequently, in equations of this line, the right-hand member in the above equations will equal 0, (§ 4, *c*.)

17. *General equation of a plane F'', which is parallel to the intersections of two planes F' and F.* The plane F'' may be represented by the equation $\frac{x}{a''} + \frac{y}{b''} + \frac{z}{c''} = 1$. The intersection of F and F' will be represented by the equations given in § 15, (Eq. 1,2,3.) But the relations of the planes will be the same, if they are removed to the origin; the equation of F″ will then become, (4,) $\frac{x}{a''} + \frac{y}{b''} + \frac{z}{c''} = 0$, (§ 14, *d*,) and the equations of the intersections of F' and F,

$$(5.)\ \frac{\gamma}{bb'} y - \frac{\beta}{cc'} z = 0,$$

$$(6.)\ \frac{\alpha}{cc'} z - \frac{\gamma}{aa'} x = 0,$$

$$(7.)\ \frac{\beta}{aa'}x - \frac{\alpha}{bb'}y = 0.$$

As the line of intersection lies wholly in the plane F'', its coördinates are also the coördinates of the plane; and therefore by introducing in the equation of the plane the values of x and y, x and z, or y and z, as obtained by means of the above equations of the line, the sought equation will be obtained.

From 6 and 7 the values z and y are deduced:

$$z = \frac{\gamma cc'}{\alpha aa'}x, \quad y = \frac{\beta bb'}{\alpha aa'}x.$$

Making the substitution of these values of y and z, in the equation of the plane F'', the equation is obtained,

$$\frac{x}{a''} + \frac{bb'\beta}{\alpha aa'b''}x + \frac{cc'\gamma}{\alpha aa'c''}x = 0,$$

and multiplying by $\frac{\alpha aa'}{x}$

$$\frac{aa'\alpha}{a''} + \frac{bb'\beta}{b''} + \frac{cc'\gamma}{c''} = 0.$$

By substituting now the values of α, β, and γ, from § 15, the desired equation for F'' results:

$$(8.)\ a''b''(a'b-ab')cc'+c''a''(c'a-ca')bb'+b''c''(b'c-bc')aa'=0.$$

18. *The normal of a plane.* The equation of the plane is as heretofore, $\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 1$. From this is required, 1st, the equation of its normal; and, 2d, the length of the same.

a. Equation of the normal. The projections of a normal, since it is a line passing through the origin, are represented by the equations, (§ 16,)

$$(9.)\ \frac{x}{\alpha} + \frac{y}{\beta} = 0, \quad (10.)\ \frac{z}{\gamma} + \frac{x}{\delta} = 0, \quad (11.)\ \frac{y}{\epsilon} + \frac{z}{\zeta} = 0.$$

Also the intersections of the given plane with the coördinate planes have the equations, (§ 14, *b*,)

$$(12.)\ \frac{x}{a} + \frac{y}{b} = 1, \quad (13.)\ \frac{z}{c} + \frac{x}{a} = 1, \quad (14.)\ \frac{y}{b} + \frac{z}{c} = 1.$$

But the projections of the normal are at right angles with these intersections, as the normal is at right angles with the plane producing these intersections, and consequently, 9 and 12 being at right angles, we have, (§§ 5 and 6,) $\alpha a + \beta b = 0$. So also from 10 and 13, 11 and 14, we deduce, $\gamma c + \delta a = 0$, $\epsilon b + \zeta c = 0$. Hence, as in § 6, there results,

$$(15.)\ \frac{x}{b} - \frac{y}{a} = 0, \quad (16.)\ \frac{z}{a} - \frac{x}{c} = 0, \quad (17.)\ \frac{y}{c} - \frac{z}{b} = 0,$$

for the equations of the normal.

b. Length of the normal. Its length, (§ 13,) $= \sqrt{x^2+y^2+z^2}$, in which

x, y, and z represent the coördinates of the intersection with the plane. To obtain its length, it is therefore necessary to determine the values of x, y, and z. Because the coördinates of the normal and plane coincide in this point of intersection, we may, as before, substitute in the equation of the plane, the values of x, y, and z, as obtained from the equation of the normal, and this will give the coördinates of the extremity of the normal, in which it coincides with the plane.

From equations 15 and 16, $y = \frac{ax}{b}$, $z = \frac{ax}{c}$, which values of y and z substituted in the equations of the plane, give

$$\frac{x}{a} + \frac{ax}{b^2} + \frac{ax}{c^2} = 1, \quad \text{or,} \quad \frac{ax}{a^2} + \frac{ax}{b^2} + \frac{ax}{c^2} = 1,$$

whence $\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2} = \frac{1}{ax}$, and consequently

$$ax = \frac{1}{\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2}}.$$

Representing the right hand member of the equation by L,

$$x = \frac{1}{a} L.$$

In the same manner it may be shown, that

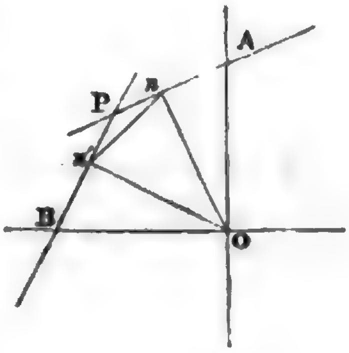
$$y = \frac{1}{b} L, \qquad z = \frac{1}{c} L.$$

Therefore, $N^2 = x^2 + y^2 + z^2 = \left(\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2}\right) L^2$

$$= \frac{1}{L} \times L^2 = L, \quad \text{and} \quad N = \sqrt{L} = \sqrt{\left(\frac{a^2 b^2 c^2}{a^2 b^2 + c^2 a^2 + b^2 c^2}\right)}$$

$$= \frac{a\,b\,c}{\sqrt{a^2b^2 + c^2a^2 + b^2c^2}}.$$

19. *Cosine of the inclination of two planes.* The angle included between the normals of two planes (that is, the angle nOn') is equal to the supplement of the inclination of the planes, (nPn';) therefore calling the former W and the latter V,



$$-\cos. W = \cos. V.$$

But, (designating the distance between the extremities of the normals, by R)

$$\cos. V \,(\text{Trigonom.}) = \frac{N^2 \times N'^2 - R^2}{2NN'}.$$

By finding the values of N, N', and R, and substituting them in the above equation, we obtain the cosine sought.

$$N^2\,(\S\,13) = x^2 + y^2 + z^2, \quad N'^2 = x'^2 + y'^2 + z'^2,$$

$$R^2\,(\S\,13) = (x-x')^2 + (y-y')^2 + (z-z')^2,$$

$$= x^2 - 2xx' + x'^2 + y^2 - 2yy' + y'^2 + z^2 - 2zz' + z'^2.$$

Consequently, after substitution and reduction, we obtain

$$\cos. V = \frac{xx' + yy' + zz'}{\sqrt{x^2 + y^2 + z^2}\,\sqrt{x'^2 + y'^2 + z'^2}}.$$

Another substitution of the values of x, x', y, y', z and z', as given in § 18, gives, after reduction,

$$\cos. V = \frac{\frac{1}{aa'} + \frac{1}{bb'} + \frac{1}{cc'}}{\sqrt{\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2}}\,\sqrt{\frac{1}{a'^2} + \frac{1}{b'^2} + \frac{1}{c'^2}}},$$

and reducing still further, we obtain

$$\cos. W = -\frac{aa'\,bb' + cc'\,aa' + bb'\,cc'}{\sqrt{a^2b^2 + c^2a^2 + b^2c^2}\,\sqrt{a'^2b'^2 + c'^2a'^2 + b'^2c'^2}}.$$

When the planes are at right angles with one another,

$$aa'\,bb' + cc'\,aa' + bb'\,cc' = 0,$$

and when parallel, $a : b : c :: a' : b' : c'$.

If one of the planes is a coördinate, one of the axes $= 0$; that is, in the coördinate plane

$$\begin{aligned} y\,z, &\quad x = a' = 0, \\ z\,x, &\quad y = b' = 0, \\ x\,y, &\quad z = c' = 0. \end{aligned}$$

Making then in the above equations a', b', and c' successively equal to 0, we obtain for the inclination with

$$yz, \quad \cos. X = \frac{bc}{\sqrt{a^2b^2 + c^2a^2 + b^2c^2}},$$

$$zx, \quad \cos. Y = \frac{ca}{\sqrt{a^2b^2 + c^2a^2 + b^2c^2}},$$

$$xy, \quad \cos. Z = \frac{ab}{\sqrt{a^2b^2 + c^2a^2 + b^2c^2}}.$$

20. *Cosine of the mutual inclinations of two lines.* These lines, if they do not pass through the origin, may be supposed to pass through it, and therefore will have the equations,

$$(18.)\ \frac{x}{\alpha} + \frac{y}{\beta} = 0, \qquad \frac{x}{\alpha'} + \frac{y}{\beta'} = 0,$$

$$(19.)\ \frac{z}{\gamma} + \frac{x}{\delta} = 0, \qquad \frac{z}{\gamma'} + \frac{x}{\delta'} = 0,$$

$$(20.)\ \frac{y}{\varepsilon} + \frac{z}{\zeta} = 0, \qquad \frac{y}{\varepsilon'} + \frac{z}{\zeta'} = 0.$$

Calling the normals of these lines D and D', and R the distance of their extremities, and U the inclination of the normals, we have, as in § 19,

$$\cos. U = \frac{D^2 + D'^2 - R^2}{2DD'} = \frac{xx' + yy' + zz'}{\sqrt{x^2 + y^2 + z^2}\ \sqrt{x'^2 + y'^2 + z'^2}}.$$

The values of y and y', z and z', may be obtained from equations 18 and 19,

$$y = -\frac{\beta x}{\alpha} \qquad y' = -\frac{\beta' x}{\alpha'},$$

$$z = -\frac{\gamma x}{\delta} \qquad z' = -\frac{\gamma' x}{\delta'}.$$

But (§ 18) $x = \frac{L}{\alpha}$, therefore,

$$y = -\frac{\beta L}{\alpha\alpha} \qquad z = \frac{\gamma L}{\alpha\delta}, \text{\&c.}$$

Substituting these values of z and y, in the above equation,

$$\cos. U = \frac{L^2 \left(\frac{1}{\alpha\alpha'} + \frac{\beta\beta'}{\alpha\alpha\alpha'\alpha'} + \frac{\gamma\gamma'}{\alpha\delta\alpha'\delta'}\right)}{L^2 \sqrt{\frac{1}{\alpha^2} + \frac{\beta^2}{\alpha^2\alpha^2} + \frac{\gamma^2}{\alpha^2\delta^2}}\ \sqrt{\frac{1}{\alpha'^2} + \frac{\beta'^2}{\alpha'^2\alpha'^2} + \frac{\gamma'^2}{\alpha'^2\delta'^2}}},$$

which reduced gives,

$$\cos. U = \frac{\alpha\alpha'\,\delta\delta' + \beta\beta'\,\delta\delta' + \gamma\gamma'\,\alpha\alpha'}{\sqrt{\alpha^2\delta^2 + \delta^2\beta^2 + \gamma^2\alpha^2}\ \sqrt{\alpha'^2\delta'^2 + \delta'^2\beta'^2 \times \gamma'^2\delta'^2}}.$$

In the same manner may be obtained from equations 19 and 20,

$$\cos. U = \frac{\gamma\gamma'\,\zeta\zeta' + \delta\delta'\,\zeta\zeta' + \epsilon\epsilon'\,\gamma\gamma'}{\sqrt{\gamma^2\zeta^2 + \delta^2\zeta^2 + \epsilon^2\gamma^2}\ \sqrt{\gamma'^2\zeta'^2 + \delta'^2\zeta'^2 + \epsilon'^2\gamma'^2}}.$$

from 20 and 18,

$$\cos. U = \frac{\epsilon\epsilon'\,\beta\beta' + \beta\beta'\,\zeta\zeta' + \alpha\alpha'\,\epsilon\epsilon'}{\sqrt{\epsilon^2\beta^2 + \beta^2\zeta^2 + \alpha^2\epsilon^2}\ \sqrt{\epsilon'^2\beta'^2 + \beta'^2\zeta'^2 + \alpha'^2\epsilon'^2}}.$$

When the lines are at right angles with one another, the numerators equal 0; that is, (from first equation of cos. U,) $\alpha\alpha'\,\delta\delta' + \beta\beta'\,\delta\delta' + \gamma\gamma'\,\alpha\alpha' = 0$; or dividing by $\alpha\alpha'\,\delta\delta'$,

$$1 + \frac{\beta\beta'}{\alpha\alpha'} + \frac{\gamma\gamma'}{\delta\delta'} = 0.$$

The second and third equations for cos. U, will give a similar equation for rectangularity.

When the lines are parallel, $\gamma : \delta = \gamma' : \delta'$, also, $\alpha : \beta = \alpha' : \beta'$ $\epsilon : \zeta = \epsilon' : \zeta'$.

II. OBLIQUE OR CLINOMETRIC SYSTEM OF AXES.

The calculations in this system may proceed either from a consideration of the inclination of the axes, or the inclination of the coördinate planes. The latter method will be adopted.

The three angles formed by the intersections of the coördinate planes, may be either all right, as is the case in the orthometric or rectangular system, or there may be,

1. Two right and one oblique;
2. One right and two oblique; or,
3. All oblique.

The first of these is termed the ***Monoclinate*** system, the second the ***Diclinate***, and the third the ***Triclinate***, the Greek numerals expressing the number of oblique angles. The Monoclinate system only will be here considered.

22. *Equation of a point, line, and plane, in the Monoclinate system.* The oblique angle is supposed to be included between the axes x and y, the remaining axis, z, being at right angles with both x and y. The equation of a point in the axis will be as in the preceding system. $x = \pm a$, $y = \pm b$, $x = \pm c$.

The equation of the plane is here also of the form

$$\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 1,$$

and the equations of the line will likewise, as in § 16, be represented by

$$\frac{x}{\alpha} + \frac{y}{\beta} = 1, \quad \frac{z}{\gamma} + \frac{x}{\delta} = 1, \quad \frac{y}{\varepsilon} + \frac{z}{\zeta} = 1.$$

In the following calculations the simplest method of arriving at the desired results, will be, to make the equations orthometric, by substituting the orthometric values of x and y, given in § 11, and then to introduce these values in the formulas already obtained. By a reversion of the first process, the formulas thus obtained may be rendered clinometric, or be made to refer to oblique axes, as in the original equation.

22. *Distance of a point from the origin, and the distance of two points.* The equation in the rectangular system for the distance of a point from the origin, is (§ 13) $D = \sqrt{x^2 + y^2 + z^2}$. If we substitute in this equation the clinometric value of x and y, as obtained in § 11, the required distance will be obtained. From § 11, $x_{,} = x + y \cos. \rho$ and $y_{,} = y \sin. \rho$. Hence by substitution,

$$D = \sqrt{x^2 + 2\,xy \cos. \rho + y^2 \cos.^2 \rho + y^2 \sin.^2 \rho + z^2},$$

which reduced, observing that $\cos.^2 + \sin.^2 = R^2 = 1$, gives

$$D = \sqrt{x^2 + y^2 + z^2 + 2\,xy \cos. \rho}.$$

In a similar manner, we deduce for the distance of two points,

$$R = \sqrt{(x-x')^2 + (y-y')^2 + (z-z')^2 + (x-x')\,(y-y') \cos. \rho}.$$

23. The equation of the line of intersection of two planes, will be the same as in § 15. So also the general equation for the parameter of a third plane parallel to the intersection of two others, will be identical with that in § 17.

24. *Normal of a plane.* The equation of the plane is

$$\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1.$$

Referred to rectangular axes, or transformed into an orthometric equation, it becomes, by substituting for

$$x, \quad x_{,}—y_{,}\frac{\cos.\rho}{\sin.\rho} \text{ (§ 11,)} \quad \text{and for } y, \quad y_{,}\frac{1}{\sin.\rho}$$

$$\frac{x_{,}}{a}+\frac{a—b\cos.\rho}{ab\sin.\rho}y_{,}+\frac{z}{c}=1,$$

from which the equations of the normal are readily deduced, in the same manner as equations 15, 16, 17, in § 18. They are,

$$(21.)\ \frac{(a—b\cos.\rho)\,x_{,}}{ab\sin.\rho}—\frac{y_{,}}{a}=0.$$

$$(22.)\ \frac{z}{a}—\frac{x_{,}}{c}=0.$$

$$(23.)\ \frac{y_{,}}{c}—\frac{(a—b\cos.\rho)\,z}{ab\sin.\rho}=0.$$

We may restore these equations to the clinometric system, by substituting for x and y their clinometric values, $x_{,}=x+y\cos.\rho$ (§ 11) and $y_{,}=y\sin.\rho$, and thus results for the desired equations,

$$(24.)\ \frac{x}{b—a\cos.\rho}—\frac{y}{a—b\cdot\cos.\rho}=0.$$

$$(25.)\ \frac{z}{ab\sin.^2\rho}—\frac{x}{c\,(b—a\cos.\rho)}=0.$$

$$(26.)\ \frac{y}{c\,(a—b\cos.\rho)}—\frac{z}{ab\sin.^2\rho}=0.$$

The coördinates of the point of intersection of the normal with the plane are easily determined, in the same manner as in § 18, by finding the value of two of the coördinates from two of the above equations, (y and z, for instance, from 24 and 25,) and substituting this value in the equation of the plane. Thus is obtained, after substituting

E for abc, F for $b—a\cos.\rho$, G for $a—b\cos.\rho$,
and M for $a^2b^2+c^2a^2+b^2c^2—ab\cos.\rho\,(2c^2+ab\cos.\rho)$,

$$x=\frac{cEF}{M} \qquad y=\frac{cEG}{M} \qquad z=\frac{ab\sin.^2\rho\,E}{M}.$$

25. *Cosine of the inclination of two planes.* The angle included by the normals of the plane being designated by V, the cosine of the sought angle $W=—\cos.V$. Let x, y, z and x', y', z' represent the *rectangular* coördinates of those extremities of the normals in which they intersect the planes,

$$\cos.V\text{ (§ 19)}=\frac{x_{,}x_{,}'+y_{,}y_{,}'+z\,z'}{\sqrt{x_{,}^2+y_{,}^2+z^2}\ \sqrt{x_{,}'^2+y_{,}'^2+z'^2}}.$$

The values of x, y, z, are determinable from the rectangular coördinates of the normals given in equations 21, 22, 23, in the same manner as they were determined from equations 15, 16, and 17, in § 18. The value thus found substituted in the above equation, gives, cos. $V =$

$$\frac{aa'\,bb'\sin.^2\rho + cc'\,[bb'\sin.^2\rho + (a-b\cos.\rho)\,(a'-b'\cos.\rho)]}{\sqrt{a^2b^2\sin.^2\rho + c^2\,[b^2\sin.^2\rho + (a-b\cos.\rho)^2]}\;\sqrt{a'^2\,b'^2\sin.^2\rho + c'^2\,[b'^2\sin.^2\rho + (a'-b'\cos.\rho)^2]}},$$

and consequently, cos. $W = -$

$$\frac{aa'\,bb'\sin.^2\rho + cc'\,(aa' + bb' - ab'\cos.\rho - a'\,b\cos.\rho)}{\sqrt{a^2b^2\sin.^2\rho + c^2\,(a^2+b^2-2\,ab\cos.\rho)}\;\sqrt{a'^2\,b'^2\sin.^2\rho + c'^2\,(a'^2+b'^2-2\,a'\,b'\cos.\rho)}};$$

from which for an angle of 90°, since the numerator must then equal 0, we have

$$aa'\,bb'\sin.^2\rho + cc'\,(aa' + bb' - ab'\cos.\rho - a'b\cos.\rho) = 0,$$

and for parallelism

$$a : b : c = a' : b' : c'.$$

The cosines of the intersection of a plane with one of the coördinate planes, may be obtained by making in the above equation, x', y', or z', that is, a', b', or $c' = 0$, as in § 19.

26. *Cosine of the inclination of two lines.* The equations of the lines removed to the origin are:

$$\frac{x}{\alpha}+\frac{y}{\beta}=0, \quad \frac{z}{\gamma}+\frac{x}{\delta}=0, \quad \frac{y}{\epsilon}+\frac{z}{\zeta}=0,$$

$$\text{and } \frac{x}{\alpha'}+\frac{y}{\beta'}=0, \quad \frac{z}{\gamma'}+\frac{x}{\delta'}=0, \quad \frac{y}{\epsilon'}+\frac{z}{\zeta'}=0.$$

Made *orthometric* by substituting for

$$x, \quad x_, - y_, \frac{\cos.\rho}{\sin.\rho}, \quad \text{for } y, \quad y_, \frac{1}{\sin.\rho}, \text{ they become}$$

$$\frac{x'}{\alpha-\beta\cos.\rho} + \frac{y_,}{\beta\sin.\rho} = 0, \qquad \frac{x_,}{\alpha'-\beta'\cos.\rho} + \frac{y_,}{\beta'\sin.\rho} = 0.$$

$$\frac{z}{\alpha\gamma} + \frac{x_,}{\delta\,(\alpha-\beta\cos.\rho)} = 0, \qquad \frac{z}{\alpha'\gamma'} + \frac{x_,}{\delta'(\alpha'-\beta'\cos.\rho)} = 0.$$

$$\frac{y_,}{\epsilon\sin.\rho} + \frac{z}{\zeta} = 0, \qquad \frac{y_,}{\epsilon'\sin.\rho} + \frac{z}{\zeta'} = 0.$$

By substituting the parameter in these equations for $\alpha, \alpha', \beta', \beta'$, &c., in the expressions for cos. U, in § 20, we obtain, cos. $U =$

$$-\frac{\alpha\alpha'\,\delta\delta' + \beta\beta'\,\delta\delta' + \alpha\alpha'\,\gamma\gamma' - \delta\delta'\,(\alpha\beta' + \alpha'\beta)\cos.\rho}{\sqrt{\alpha^2\,\epsilon^2 + \beta^2\,\epsilon^2 + \beta^2\,\zeta^2 - 2\,\alpha\beta\epsilon^2\cos.\rho}\;\sqrt{\alpha'^2\,\epsilon'^2 + \beta'^2\,\epsilon'^2 + \beta'^2\,\zeta'^2 - 2\alpha'^2\,\beta'\,\epsilon'^2\cos.\rho}};$$

or from the other value of the cos. U, cos. $U =$

$$-\frac{\alpha\alpha'\,\epsilon\epsilon' + \beta\beta'\,\epsilon\epsilon' + \beta\beta'\,\zeta\zeta' - \epsilon\epsilon'\,(\alpha\beta' + \alpha'\beta)\cos.\rho}{\sqrt{\alpha^2\,\epsilon^2 + \beta^2\,\epsilon^2 + \beta^2\,\zeta^2 - 2\,\alpha\beta\epsilon^2\cos.\rho}\;\sqrt{\alpha'^2\,\epsilon'^2 + \beta'^2\,\epsilon'^2 + \beta'^2\,\zeta'^2 - 2\,\alpha'\,\beta'\,\epsilon'^2\cos.\rho}},$$

which are the sought values of the cosine of the angle of the inclination of two lines.

MATHEMATICAL CRYSTALLOGRAPHY.

CRYSTALLOGRAPHIC SIGNS, OR EXPRESSIONS FOR THE PLANES OF CRYSTALS.

26. It is apparent that all the faces of a crystal either intersect one or more of the crystallographic axes, or would intersect them if sufficiently extended in each direction. The faces of the octahedron intersect its three axes at equal distances from the centre; similarly the incipient faces of the octahedron, on the cube, (fig. 2,) would intersect the three axes, if enlarged in each direction. The faces of the cube intersect but one axis, being parallel to the other two. But it is too manifest to require explanation, that all the planes which can occur in the cube, octahedron, &c., if sufficiently enlarged would intersect one or more of the three axes.

The situation of a plane may therefore be expressed by stating the relative distances from the centre of the intersections of this plane with the axes which it meets, or would meet if extended. For the faces of the octahedron, we might write $1:1:1$, understanding by it that these faces cut each of the three axes at equal distances from the centre. A truncation of the edges of the octahedron (fig. 9) produces planes which meet two axes at equal distances from the centre, and are parallel to the third. Its intersection with this third axis may be said to be at an infinite distance. Using the usual sign for infinity ∞, we might express the situation of these planes by the ratio $1:1:\infty$. The truncation of an angle gives rise to a face of a cube which intersects but one axis, being parallel to the remaining two; its descriptive expression might therefore be $1:\infty:\infty$.

From a bevelment of the edges of the octahedron (fig. 21) arise two planes, each of which intersects two axes at equal distances from the centre, and the third at a varying distance. If this distance be twice as great as that of the other two, the planes might be described by the ratio $1:1:2$, if three times $1:1:3$, &c. The intermediate planes (fig. 26) will intersect each of the axes at a different distance from the centre; if the distances are as $4 : 2 : 1$, this ratio might be used to express the situation of the planes.

In general, therefore, writing m and n for any numerical values that may be substituted, $m : n : 1$, will express the situation of any plane in the class Monometrica.

In primary forms of unequal axes, if a, b, c, represent the axes, $ma : nb : c$, or $ma : b : rc$, will express the situation of any plane that may occur upon them.

Such in general is the system of crystallographic notation proposed by Weiss. Its beauty and importance will be apparent when it is considered that these expressions for planes are identical with the parameters of the same planes; and that by means of them we are consequently enabled to apply to crystals the principles of analytical geometry. With a knowledge of these indices of the planes, we have sufficient data for a determination of every angle in the crystal.

27. This system of notation has been variously simplified. The method proposed by Naumann, in his treatise on crystallography, will be here adopted.

In the above expressions for planes, one quantity may in all instances be a unit, since merely the relative values of the parameters are required. $8 : 6 : 4$, $4 : 3 : 2$, $2 : \frac{3}{2} : 1$, are identical ratios: either may therefore be employed.

Since then one figure may be a unit, we need express only the other two. It is found most convenient to write these two quantities, one on each side of a letter, which may be assumed to represent the *fundamental form*; that is, the form which proceeds from the simple ratio $1 : 1 : 1$; as for example, the regular octahedron. Asuming the letter O for this purpose, the above ratio will be written $2\ O\ \frac{3}{2}$. In a similar manner for the ratio $2 : 1 : 1$, we write $2\ O$; it being unnecessary to repeat the unit after the O. Also for $1 : 1 : 1$, we write O. $2 : 2 : 1 = 2\ O\ 2$; $\infty : 1 : 1 = \infty O$; $\infty : \infty : 1 = \infty O \infty$. $m\ O\ n$ is a general expression for all faces, and becomes O simply when $m = n = 1$; becomes ∞O when $m = \infty$, and $n = 1$, &c.

Designating the fundamental octahedron in the other classes by **P**, **$m\ P\ n$** will be a general representative of planes in these classes.

GENERAL REMARKS ON THE DETERMINATION OF THE PARAMETERS OF PLANES WITH PARALLEL INTERSECTIONS.

28. The plane o′ in figure 1, page 406, makes parallel intersections with o″ and a′. By means of the formulas in § 17, we are enabled to determine the relative values of m and n, for the plane o′, when we have given the parameters of the planes o″ and a′, with

which the intersections of o′ are parallel. To obtain this result, we introduce into the formula the numerical values of the parameters of a′, for a, b, c, and the same of o″, for a', b', c': after a reduction of the equation we obtain the relative values of a'', b'', c'', or the sought parameter of o′.

The general expression for the parameter of a plane is,

$$m\,a : n\,b : r\,c,$$

which might therefore be substituted for a, b, c, in the equation, § 17. But since a, b, c, are the axes, and consequently of fixed value in the same crystal, m, n, r, or the coefficients of the axes, only remain to be determined. We may therefore substitute in the equation, § 17, m, n, r, for a, b, c; m', n', r', for a', b', c'; m'', n'', r'', for a'', b'', c'', and the equation becomes

$$m''n''(m'n-mn')rr'+r''m''(r'm-rm')nn'+n''r''(n'r-nr')mm'=0,$$

which is important in determining the relative values of m'', n'', r'', in all the classes of crystals. These being obtained, the relative values of the axes may be ascertained by multiplying m'', n'', r'', respectively into the length of the axes a, b, c. The example above alluded to may now be worked out.

The parameters of a′ $= 2 : 1 : 2 = m : n : r$.
" " " o″ $= 4 : 2 : 1 = m' : n' : r$.

By substituting these values of m, n, r, and m', n', r', we obtain

$$2\,n'' = m''.$$

Having determined this relative value of n and m, the exact value might be obtained by measurement, in a manner hereafter to be explained; or if 2 O made parallel intersections with any other two planes, another relation obtained in a similar manner in connection with the above $2\,n = m$, would decide the sought parameter of this plane, without a measurement. Its sign, as determined in either of these ways, is 3 O $\frac{3}{2}$, in which $2 \times \frac{3}{2} = 3$, agreeably to the above equation, $2\,n = m$.

If $m = n$ in the above formula, it is apparent that by substituting m for n, we simplify the equation for this particular case. In the same manner, also, there may be a further simplification, if m or $n = 1$; and also, if m' equals n', unity, or ∞.

29. The following table contains the formula simplified for the different values of m, n, and m', n':

a. $m\ P\ n$,

$m'\ P\ m', (n' = m')$	1. $m''(m - m')n + n''(m' - n)m - m''n''(m - n) = 0.$
$m'\ P\ 2, (n' = 2)$	2. $m''n''(m'n - 2m) + 2m''(m - m')n + n''(2 - n)mm' = 0.$
$m'\ P, (n' = 1)$	3. $m''n''(m'n - m) + m''(m - m')n + n''(n - 1)mm' = 0.$
$m'\ P\ \infty$	4. $m''(m - m')n + n''(m' - m'')m = 0.$
$\infty\ P\ n', (m' = \infty)$	5. $m''(n'' - n')n + n''(n' - n)m = 0.$
$\infty\ P\ 2$	6. $m''(2 - n'')n - n''(2 - n)m = 0.$
$\infty\ P$	7. $m''(n'' - 1)n - n''(n - 1)m = 0.$
P	8. $m''(m - 1)n - n''(n - 1)m - m''n''(m - n) = 0.$
$\infty\ P\ \infty$	9. $\frac{m''}{n''} = \frac{m}{n}.$
$0\ P$	10. $n'' = n.$

b. $m\ P\ m$, in which $n = m$,

$m'\ P, (n = 1)$	1. $m''n''(m' - 1) + m''(m - m') - n''(m - 1)m' = 0.$
$m'\ P\ \infty$	2. $m''(m - m')m + n''(m' - m'')m = 0.$
$\infty\ P\ n', (m = \infty)$	3. $m''(n'' - n') + n''(n' - m) = 0.$
$\infty\ P$	4. $m''(n'' - 1) - n''(m - 1) = 0.$
P	5. $m'' = n'', m'' < m.$
$\infty\ P\ \infty$	6. $m'' = n'', m'' > m.$

c. $m\ P\ 2$, in which $n = 2$,

$m'\ P$	1. $m''n''(m - 2m') + 2m''(m' - m) + mm'n'' = 0.$
$m'\ P\ \infty$	2. $2m''(m - m') + n''(m' - m'')m = 0.$
$\infty\ P\ n$	3. $2m''(n'' - n') - n''(2 - n')m = 0.$
$\infty\ P$	4. $n''(2m'' - m) - 2m'' = 0.$

d. $m\ P$, in which $n = 1$,

$m\ P\ \infty$	1. $m''(m - m') + n''(m' - m'')m = 0.$
$\infty\ P\ n'$	2. $m''(n'' - n') + n''(n' - 1)m = 0.$
$\infty\ P\ 2$	3. $2m'' - n''(m'' + m) = 0.$
$\infty\ P$	4. $n'' = 1, m'' > m.$
P	5. $n'' = 1, m'' < m.$
$\infty\ P\ \infty$	6. $\frac{m''}{n''} = m.$

e. $m\ P\ \infty$, in which $n = \infty$,

$\infty\ P\ n'$	1. $n''(m'' - m) - m''n' = 0.$
$\infty\ P$	2. $n''(m'' - m) - m'' = 0.$

f. $\infty\ P\ n$, in which $m = \infty$.

P	1. $m''(n'' - n) + n''(n - 1) = 0.$

If a plane forms parallel intersections with the two planes $m\ P\ n$ and $m'\ P$, (n' being equal to 1 in the latter expression, $m'\ P$,) in order to find the relation of m and n in the plane, we may employ the equation opposite $m'\ P$, and under the general head $m\ P\ n$, instead of the longer equation on the preceding page. Or if the plane was situated between $m\ P\ m$ and $\infty\ P\ n'$, the short equation under $m\ P\ m$, and opposite $\infty\ P\ n'$, should be employed. In using the long equation it would be necessary to substitute m for n, and ∞ for m', and perform the reduction consequently required: in the simplified equation, this substitution has already been made.

CLASS MONOMETRICA.

I. CRYSTALLOGRAPHIC SIGNS OF MONOMETRIC CRYSTALLINE FORMS.

1. *Holohedral Forms.*

30. *a. Cube.* The faces of the cube intersect but one axis; the sign of each is therefore $\infty : \infty : 1$, or $\infty O \infty$.

b. Dodecahedron. The dodecahedral faces, e, figs. 5, 6, 7, 8, 9, meet two axes equally, and are parallel to a third. Their ratio is therefore $\infty : 1 : 1$, and their sign ∞O.

c. Trigonal Trisoctahedron, fig. 20. As this solid proceeds from a bevelment of the edges of the octahedron, fig. 21, the planes a″ would meet one axis at 2, 3, or 4, &c. times from the centre, that it meets the other two. Its ratio is in general, therefore, $m : 1 : 1$, m standing for the varying axis; and the sign is $m O$. $\frac{3}{2} O$, $2 O$, $3 O$, occur in nature.

d. Tetragonal Trisoctahedron, fig. 16. The planes of this solid upon the octahedron are seen at a′, fig. 17, where it appears, that if extended they would intersect two axes equally, but at a greater distance from the centre than their intersection with the other axis; it may be *two* or *three* times, &c. The general ratio is, therefore, $1 : m : m$, and the sign $m O m$. The usual occurring forms are $2 O 2$ and $3 O 3$.

e. Tetrahexahedron, fig. 11. These planes on the octahedron are seen at e′, fig. 12, where (observing the horizontal one in front) it is obvious that they would intersect two axes unequally, and be parallel to the third. Their ratio may therefore be $\infty : n, 1$, and hence the crystallographic sign $\infty O n$. $\infty O 2$, $\infty O 3$, have been observed in nature.

f. Hexoctahedron, fig. 25. These forms result from intermediate planes, and have therefore the general ratio $m : n : 1$, and the sign $m O n$. The forms $3 O \frac{3}{2}$, $4 O 2$, $5 O \frac{5}{3}$, are of common occurrence.

2. *Hemihedral Forms.*

31. These solids have the sign of the corresponding holohedral, with the addition of a denominator 2: thus the tetrahedron is designated $\frac{O}{2}$.

The tetrahedron may be formed on the angles truncated in fig. 28, or on those which are not truncated. To distinguish the two, which have a different position, (figs. 30, 31,) the sign + or — is affixed.

In a similar manner, we have for the hemi-trisoctahedrons, $\pm\frac{m\,O}{2}$ and $\pm\frac{m\,O\,m}{2}$; and for the hemi-hexoctahedron, fig. 41, $\pm\frac{m\,O\,n}{2}$.

Another kind of hemi-hexoctahedron has been described as formed by three intermediary planes on each angle of the cube. These, unlike the preceding, have opposite parallel faces, (figs. 48, 49.) They may be distinguished as follows: $\pm\frac{[m\,O\,n]}{2}$.

In the same manner, the hemi-tetrahexahedrons, (fig. 44,) which also have opposite parallel faces, may be designated $\pm\frac{[\infty\,O\,n]}{2}$.

II. MATHEMATICAL DETERMINATION OF THE INTERFACIAL ANGLES OF THE SIMPLE MONOMETRIC SOLIDS.

It has already been stated that the crystallographic signs just explained are expressions for the parameters of the planes, and that, consequently, by means of the data they afford, the principles of Analytical Geometry may be applied to the calculations of the interfacial and plane angles, and also, if desired, the superficial and solid contents of crystals.

1. *Holohedral Forms.*

32. The interfacial angles may be obtained by means of the equation, § 19 of the Analytical Geometry, in which the cosine of the inclination of two planes is given in terms of the parameters. In the first place, we take the most general case, and determine the formulas for the inclinations of the planes O, O', O'', O''', fig. 25.

Since $m\,O\,n$ is the general expression for the planes, the equation of the face O is

$$\frac{x}{m} + \frac{y}{n} + z = 1.$$

m, n, 1, are therefore the values of a, b, c, in the general formula for the sought cosine, § 19. The corresponding values of a', b', c', may be obtained severally from the equations of O', O'', or O'''. The equation for O' is

$$\frac{x}{n} + \frac{y}{m} + z = 1\,; \quad \text{for } O'', \quad \frac{x}{-m} + \frac{y}{n} + z = 1.$$

The first term is here minus, because O'' intersects the axis x below the plane $y\,z$. For O''' the corresponding equation is

$$\frac{x}{m} + y + \frac{z}{n} = 1.$$

Hence for the angle A between O and O', $a', b', c', = n, m, 1$.
" " B " O and O'', $a', b', c', = -m, n, 1$.
" " C " O and O''', $a', b', c', m, 1, n$.

Substituting the values $m, n, 1$, obtained from O, for a, b, c, in the equation of cos. W, § 19, and the above values successively of a', b', c', we obtain

$$\text{Cos. } A = -\frac{m\,n\,(m\,n+2)}{m^2\,(n^2+1)+n^2}, \qquad \text{Cos. } B = -\frac{m^2\,(n^2+1)-n^2}{m^2\,(n^2+1)+n^2},$$

$$\text{Cos. } C = -\frac{n\,(2\,m^2+n)}{m^2\,(n^2+1)+n^2}.$$

If $m O n = 4\ O\ 2$, by substituting 4 and 2 for m and n, in the above equations, the actual values of these angles in the hexoctahedron $4\ O\ 2$, may be determined. And whatever values m or n may have, by substituting their values, the angles in that particular instance may be ascertained. If $m = \infty$, as in the tetrahexahedrons, cos. $A = -\frac{n}{n^2+1}$, cos. $B = -1 = 180°$, and cos. $C = -\frac{2n}{n^2+1}$. In this solid the planes O and O'' are in the same plane, making the angle $B = 180°$. In the dodecahedron the angle between O and O'', and also O and O''', that is, B and C, each equal 180°. In the cube each of the angles A and $B = 180°$.

Similarly in the other monometric solids one or more of the angles A, B, C, become equal to 180°. This may be observed by comparing the situation of the planes of these solids with those of the hexoctahedron.

2. *Hemihedral Forms.*

33. *a. Inclined hemihedrons.* O, O', O''', fig. 41, have the same relative situation as the same faces in fig. 25. A' and C' are, therefore, determined by the same formulas. To determine the interfacial angle of B', the equation of O is

$$\frac{x}{m} + \frac{y}{n} + z = 1.$$

The equation of O'' is

$$\frac{x}{-n} + \frac{y}{-m} + z = 1.$$

$m, n, 1$, being substituted for a, b, c, and $-n, -m, 1$, for a', b', c', we obtain

$$\text{Cos. } B' = -\frac{m\,n\,(m\,n-2)}{m^2\,(n^2+1)+n^2}.$$

By substituting the different numerical values of m and n, whatever they may be, from 1 to ∞, the corresponding angles for the other inclined hemihedrons may be obtained. Excepting in the hemihexoctahedrons, one or more of the angles A', B', C', become equal to 180°. In the hemi-octahedron or tetrahedron, *A* and *C* both equal 180°.

b. Parallel hemihedrons. We take again the most general case, a hemihedral form of a hexoctahedron, *m O n*, represented in fig. 49. The planes including *B''* have a similar situation with those including the same interfacial angle in fig. 25. It is determined, therefore, by the same formula. For the other angles we have the equation of

$$O, \frac{x}{m} + \frac{y}{n} + z = 1; \quad O'', x + \frac{y}{m} + \frac{z}{n} = 1; \quad O', \frac{x}{m} - \frac{y}{n} + z = 1.$$

By substituting first the values of the parameters of *O* and *O'*, and then those of *O* and *O''*, in the general equation for the cosine of interfacial angles, we find

$$\text{Cos. } A'' = -\frac{m^2(n^2-1)+n^2}{m^2(n^2+1)+m^2}, \qquad \text{Cos. } C'' = -\frac{mn(m+n+1)}{m^2(n^2+1)+n^2}.$$

Also as above obtained,

$$\text{Cos. } B'' = \text{Cos. } B = -\frac{m^2(n^2+1)-n^2}{m^2(n^2+1)+n^2}.$$

When $m = \infty$, as in the hemi-tetrahexahedron, fig. 44,

$$\text{Cos. } A'' = -\frac{n^2-1}{n^2+1}; \quad \text{Cos. } B'' = -1; \quad \text{Cos. } C'' - \frac{n}{n^2+1}.$$

In this solid the angle *B''* becomes equal to 180°.

The formulas for the plane angles of these hemihedral and holohedral solids, are easily deduced from the equations for the inclinations of two lines in space, § 20. They are of little importance to the mineralogist, and are therefore not given in this place.

III. INTERFACIAL ANGLES BETWEEN TWO DIFFERENT FORMS.

1. *Holohedral Forms.*

34. To determine the inclination of $4O2$ on $3O\frac{3}{2}$, or, in general, *m O n* on *m' O n'*, it is necessary to substitute *m*, *n*, 1, for *a*, *b*, *c*, and *m'*, *n'*, 1, for *a'*, *b'*, *c'*, as heretofore, in the general equation for the cosine of the inclination of two planes, § 19. If this substitution be made, the equation becomes

$$\text{Cos. } Q \text{ (the sought inclination)} = -\frac{mm'(nn'+1)+nn'}{\sqrt{m^2(n^2+1)+n^2}\ \sqrt{m'^2(n'^2+1)+n'^2}}.$$

By writing the numerical values of *m n*, and *m' n'*, in any instance, the sought angle is obtained. This formula may be simplified for particular values of m and n. A few of these formulas are given in the following table, in which M is written for

$\sqrt{m^2(n^2+1)+n^2}$, and M' for $\sqrt{m'^2(n'^2+1)+n'^2}$.

	$\infty O \infty$	$\infty O n'$	$m' O m'$
$m O n$	$\frac{m\,n}{M}$	$\frac{m\,(n\,n'+1)}{M\sqrt{n'^2+1}}$	$\frac{m\,(m'\,n+1)+n}{M\sqrt{(m'^2+2)}}$
$\infty O n$	$\frac{n}{\sqrt{n^2+1}}$	$\frac{n\,n'+1}{\sqrt{(n^2+1)(n'^2+1)}}$	

If the forms under consideration were $4 O 2$ and $2 O 2$, the angle might be obtained by substituting in the formula opposite $m O n$, $m' O m'$, 4 2, for m n, and 2, for m'; and by performing the reduction, the cosine of the required angle would be determined. If the forms were $4 O 2$ and $\infty O 3$, we should substitute in the formula for $m O n$, $\infty O n'$, 4 2, for m n, and 3 for n'; or if the general formula for cos. Q were used, it would be also necessary to put ∞ for m'.

2. *Hemihedral Forms.*

35. *a. Inclined hemihedrons.* When the form has the same relative position, that is, are either both plus, or both minus, the formula is the same as for holohedral forms. But when one is plus and the other minus, the formula becomes

$$\text{Cos. } Q = -\frac{m\,m'(n\,n'+1)-n\,n'}{\sqrt{m^2(n^2+1)+n^2}\;\sqrt{m'^2(n'^2+1)+n'^2}}.$$

If one of the forms is a tetrahedron, $-\frac{O}{2}$, the equation becomes

$$\text{Cos. } Q = -\frac{m\,(n+1)-n}{M\sqrt{3}}.$$

b. Parallel hemihedrons. On account of the unsymmetrical character of the parallel hemi-hexoctahedrons, the planes of one of these solids situated on another, make a different angle with the three adjacent planes. Formulas may be deduced for the three; we give here, however, only the formulas for the interfacial angles between two analogous planes. If the solids are both plus or both minus, that is, have a like position, the formula is identical with that for the holohedral forms:

$$\text{Cos. } Q'' = -\frac{m\,n'\,(n\,n'+1)+n\,n'}{M\,M'}.$$

If unlike,

$$\text{Cos. } Q'' = -\frac{m'\,n\,(mn'+1)+m\,n'}{M\,M'}.$$

By reduction we obtain for the cosine of the interfacial angle

$$\frac{[mOn]}{2} \text{ on} - \frac{[\infty On']}{2} = \frac{n\,(m\,n'+1)}{M\sqrt{(n'^2+1)}};$$

also of $\frac{[\infty O\,n]}{2}$ on $-\frac{[\infty On']}{2} = \frac{n\,n'}{\sqrt{(n^2+1)}\ \sqrt{(n'^2+1)}}$.

IV. DETERMINATION OF THE CRYSTALLOGRAPHIC SIGNS OF PLANES BY INSPECTION.

36. The method of determination depends on an observation of the parallelism of edges, and of the forms of faces. The general equations have already been given in § 29. It will be convenient to have the several deduced formulas arranged in a table, where they may be referred to in investigations on this subject. An example in § 28, explains the method of deducing these formulas.

1. *Holohedral.*

a. Combinations of mOn, (fig. 25.)

$m'Om'$	1. Truncation of edge A of mOn,*	$m'=\frac{2mn}{m+n}$
$m'O$	2. Truncation of edge C of mOn,	$m'=\frac{m(n+1)}{2n}$
$\infty On'$	3. Truncation of edge B of mOn,	$n'=n$
∞O	4. Truncation of solid angle a by rhombic plane,	$n=\frac{m}{m-1}$
O	5. Truncation of solid angle b,	$n=\frac{2m}{m+1}$

b. Combinations of mOm, (fig. 16.)

$m'On'$	1. Rep. of S-A. a, of mOm by 4 pl. I-E. with the same face of mOm, par.†	$\frac{1}{2}m=\frac{m'n'}{m'+n'}$
$m'O$	2. Trunc. of edge C of mOm,	$m'=\frac{m+1}{2}$
	3. Rep. of S-A. a by 2 pl. inc. on edge C, I-E. par. to edge B of mOm,	$m'=m$
$\infty On'$	4. Trunc. of edge B.	$n'=m$
	5. Rep. of S-A. a, by 2 pl. inc. on B. I-E. of 2 pl. with the same face of mOm parallel,	$n'=\frac{1}{2}m$

---

* The above, written in full, would read, *A* face of $m'Om'$, truncates the longest edge of mOn, or edge A, when m' (of $m'Om'$) $=\frac{2mn}{m+n}$.

† The following abbreviations have been used in this and other similar tables: *Trunc.*, truncation; *Rep.*, replacement; *Bev.*, bevelment; S-A. solid angle; I-E, edge of intersection of two planes; *Par.*, parallel; *Pl.*, planes; *Inc.*, inclined; *Rbc.*, rhombic.

	6. Rep. of S-A. $2c$, by 4 pl. inc. on B. I-E. par. to C,	$n'=m+1$
∞O	7. Tr. of S-A. a; I-E. of 2 pl. with the same face of mOm parallel; fig. 18, planes E,	$m=2$

c. mO, (fig. 20.)

$m'On'$	1. Rep. of S-A. c of mO by 8 pl.; I-E. of two planes inc. on the same face of mO parallel,	$2m=\frac{m'(n'+1)}{n'}$
$m'Om'$	2. Rep of S-A. c, by 4 pl. inc. on A.; I-E. of two pl. with the same face of mO parallel,	$m'=2m-1$
	3. Trunc. of edge A,	$m'=\frac{2m}{m+1}$
	4. Rep. of S-A. c, by 4 rbc. pl. inc. on A. of mO, (fig. 22,)	$m'=m$
$\infty On'$	5. Rep. of S-A. c, by 4 rbc. pl. inc. on B,	$n'=\frac{m}{m-1}$
	6. Rep. of S-A. c by 4 pl. inc. on B.; I-E. with a face of mO, par. to edge A. (fig. 23,)	$n=\frac{m'^2-1}{m'^2-m'}$
∞O	7. Trunc. of edge B,	

d. ∞On, (fig. 11.)

$m'On'$	1. Rep. of S-A. b, by 6 pl. I-E. of two pl. inc. on same face of ∞On, parallel,	$n'=n$
$m'Om'$	2. Trunc. of edge A. of ∞On,	$m'=2n$
	3. Rep. of S-A. b, by 3 rbc. pl. inc. on edges A,	$m'=n+1$

e. ∞O, (fig. 7.)

$m'On'$	1. Bev. of edges of ∞O, (fig. 27,)	$n'=\frac{m'}{m'-1}$
$m'Om'$	2. Trunc. of edges of ∞O, (fig. 18,)	$m'=2$
$m'O$	3. Rep. of obtuse S-A. of ∞O, by 3 pl. inc. on faces of ∞O.	

f. O, (fig. 4.)

$m'On'$	1. Rep. of S-A. of O, by 8 pl. (fig. 26.)	
$m'Om'$	2. Rep. S-A. of O, by 4 pl. inc. on faces of O, (fig. 17.)	

g. $\infty O \infty$, (fig. 1.)

$m'On'$	1. Rep. of S-A. by 6 pl. (fig. 24.)	
$m'Om'$	2. Rep. of S-A. by 3 pl. inc. on primary faces, (fig. 14.)	
$m'O$	3. Rep. the same inc. on edges, (fig. 19.)	

37.—2. *Hemihedral.*

a. Combinations of $\frac{mOm}{2}$, (fig. 34.)

$+\frac{m'O}{2}$	1. Trunc. of edge C', (fig. 37.)	$m'=\frac{m+1}{2}$
$\infty On'$	2. Rep. of acute S-A. by 6 pl.; I-E. par. to edge $C,'$ (fig. 38,)	$n'=m+1$
∞O	3. Rep. of ac. S-A. by 3 rbc. pl.; I-E. of two pl. with a face of $\frac{mOm}{2}$, parallel, (fig. 36,)	$m=2$

$\infty O \infty$	4. Trunc. of edge *B′*.	
$+\frac{O}{2}$	5. Trunc. of obtuse S-A. (fig. 35.)	
$-\frac{O}{2}$	6. Trunc. of acute S-A.	
	b. $\frac{[mOn]}{2}$, (fig. 49.)	
$\frac{[m'On']}{2}$	1. Bev. of edge *B*.	$m'=n$ and $m'>m$
	2. Bev. of *A*.	$m'=m$ and $n'>n$
	3. Rep. of edge *C*. by plane inclined towards edge *B*.	$n'=\frac{m'(m^2-n)n}{(mn-1)mn+m'(m-n^2)m}$
	4. Rep of edge *C*. by plane inc. towards edge *A*.	$n'=\frac{m'(mn-1)mn}{m'(m^2-n)n-(m-n^2)m}$
$\frac{[\infty On']}{2}$	5. Trunc. of edge *B*. of $\frac{[mOn]}{2}$	$n'=n$
$-\frac{[\infty On']}{2}$	6. Trunc. of edge *A*.	$n'=m$
$m'Om'$	7. Bev. of edge *A*.	$m'=m$
	8. Rep. of edge *C*.	$m'=\frac{(mn-1)mn+(m-n^2)m}{(m^2-n)n}$
	c. $\frac{[\infty On]}{2}$, (fig. 44.)	
$-\frac{\infty On}{2}$	1. Rep. of inequilateral S-A. c'' by pl. inc. on edge A'' I-E. par. to transverse diagonal,	$n'=n$
O	2. Trunc. of equilateral S-A. (figs. 45, 46, 47.)	

38.—V. FORMULAS FOR THE PARAMETERS OF PLANES FORMING PARALLEL INTERSECTIONS WITH THE PLANES OF THE INCLINED HEMIHEDRONS.*

	a. $\frac{mOn}{2}$,
$\frac{m'On'}{2}$	$m''n''(m'n+mn')-m''(m+m')nn'+n''(n'-n)mm=0.$
$\frac{m'O}{2}$	$m''n''(m'n+m)-m''(m+m')n-n''(n-1)mm'=0.$
$\frac{O}{2}$	$m''n''(m+n)-m''(m+1)n-n''(n-1)m=0.$

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* The corresponding formulas for the holohedral solids have been given in § 29.

	b. $\frac{mOm}{2}$,
$\frac{m'Om'}{2}$	$2m''n'' - m''(m + m') + n''(m' - m) = 0.$
$\frac{m'O}{2}$	$m''n''(m' + 1) + m''(m + m') - n''(m - 1)m' = 0.$
$\frac{O}{2}$	$2m''n'' - m(m + 1) - n''(m - 1) = 0.$

VI. DETERMINATION OF THE SIGNS OF PLANES BY CALCULATION.

39. For the determination of the values of m and n from the interfacial angles, the following formulas may be employed. In them, the letter ν represents half the inclination of B on B over the angle c, (fig. 25 :) δ represents half the inclination of B on B over the angle a ; δ' represents the inclination of C on the horizontal basal section ; ε represents the inclination of C on the diagonal, which connects the solid angle b with its opposite. $\text{Tan.}\,\varepsilon = \frac{(n-1)\sqrt{3}}{n+1}$.

a. 1. If A and B be given in a hexoctahedron :

$$\text{Cos.}\,\nu = \frac{\cos.\tfrac{1}{2}A\sqrt{2} + \cos.\tfrac{1}{2}B}{\sin.\tfrac{1}{2}B};\ \ n = \tan.\,\nu;\ \ m = \tan.\tfrac{1}{2}B\sin.\,\nu.$$

2. If C and A be given :

$$\text{Cos.}\,\varepsilon = \frac{2\cos.\tfrac{1}{2}A + \cos.\tfrac{1}{2}C}{\sin.\tfrac{1}{2}C\sqrt{3}};\ \delta' = 144^\circ\,44' - \varepsilon;\ \tan.\,\delta = \sin.\,\delta'\tan.\tfrac{1}{2}C;$$

$$n = \tan.\,(135^\circ - \delta\,;)\qquad \frac{m(n+1)}{n} = \tan.\,\delta'\sqrt{2}.$$

3. If B and C be given :

$$\text{Cos.}\,\delta = \frac{\cos.\tfrac{1}{2}C}{\cos.\tfrac{1}{2}B};\ \nu = 135^\circ - \delta;\ \ n = \tan.\,\nu;\ \ m = \tan.\tfrac{1}{2}B\sin.\,\nu.$$

b. If in the solid mOm, in which $\frac{1}{2}A = 90^\circ$,
1. B be given : $\cos.\,\nu = \cot.\tfrac{1}{2}B$; $m = \tan.\,\nu$.
2. C be given : $\cos.\,\varepsilon = \cos.\tfrac{1}{2}C\sqrt{\tfrac{1}{3}}$; $\delta' = 144^\circ\,44' - \varepsilon$; $m + 1 = \tan.\,\delta'\sqrt{2}$.
c. If in the solid mO, in which $n = 1$ and $\frac{1}{2}C = 90^\circ$,
1. B be given : $m = \tan.\tfrac{1}{2}B\sqrt{\tfrac{1}{2}}$.
2. A be given : $\cos.\,\varepsilon = 2\cos.\tfrac{1}{2}A\sqrt{\tfrac{1}{3}}$; $\delta' = 144^\circ\,44' - \varepsilon$; $m = \tan.\,\delta'\sqrt{\tfrac{1}{2}}$.
d. If in ∞On, in which $m = \infty$ and $\frac{1}{2}B = 90^\circ$.
1. A be given : $\cos.\,\nu = \cos.\tfrac{1}{2}A\sqrt{2}$; $n = \tan.\,\nu$.
2. C be given : $n = \tan.\,(135^\circ - \tfrac{1}{2}C.)$

VII. EXAMPLES OF THE APPLICATION OF THE PRECEDING PRINCIPLES TO THE DETERMINATION OF THE SIGNS OF PLANES OF MONOMETRIC CRYSTALS.

1. *Red Copper Ore.* (See figure of this species, p. 362.)

40. This figure represents an octahedron with truncated and beveled edges, and replaced angles.

A is a face of the octahedron, which $=O$.

e truncates the edges, and is therefore the face of a dodecahedron, (fig. 9,) $=\infty O$.

p truncates a solid angle, and is therefore a face of a cube, (fig. 3,) $=\infty O \infty$.

Of the remaining faces,

a″	is of the general form		$m\ O$ (comp. fig. 21.)
e′	"	"	$\infty\ O\ n$ (comp. fig. 23.)
a′	"	"	$m\ O\ m$ (comp. fig. 17.)
o	"	"	$m\ O\ n$ (comp. fig. 27.)

a′ truncates an edge between two planes e, ($\infty\ O$;) its sign is therefore $2\ O\ 2$, (§ 36, *e*, 2, and fig. 18.)

To determine a″ ($m\ O$) we measure the inclination of e on a″ = 160° 32′. Subtracting 90°, 70° 32′ remain, which equal half the interfacial angle a″ : a″ = $\frac{1}{2}$ B, (fig. 20;) using the formula, § 39, *c*, 1, $m = \text{tan.}\ \frac{1}{2} B \surd \frac{1}{2}$, we find that $m=2$. The sign of a″ is therefore $2O$.

The faces o (mOn) bevel the edges of ∞O, and therefore (§ 36, *e*, 1) $n=\frac{m}{m-1}$. To determine n, we measure the angle o : e and find its value 160° 54′; the supplement of which, 19° 6′, is the angle ε, (§ 39.) But according to § 39, $\text{tan.}\ \varepsilon = \frac{(n-1)\surd 3}{n+1}$, and therefore by transposition $n = \frac{\surd 3 + \text{tan.}\ \varepsilon}{\surd 3 - \text{tan.}\ \varepsilon}$.

Making $\varepsilon = 19°\ 6'$, and observing that tan. $19°\ 6' = \frac{1}{5}\surd 3$, we obtain $n=\frac{3}{2}$. And since $n=\frac{m}{n-1}$, $\frac{3}{2}=\frac{m}{m-1}$, $\therefore m=3$, and the ascertained sign is $3O\frac{3}{2}$.

This could have been determined without measurement, if the planes o were so extended as to form an edge with the plane A. Two opposite planes o would then have made parallel intersections with O, and consequently, (§ 36, *a*, 5,) we should have had $n=\frac{2m}{m+1}$. Therefore since also $n=\frac{m}{m-1}$, $\frac{m}{m-1}=\frac{2m}{m+1}$; from which we find $m=3$, as before determined.

The signs of the planes collected together form the following description of the crystal :

$O.$	$2O2.$	$\infty O.$	$\infty O \infty.$	$2O.$	$\infty O2.$	$3O\frac{3}{2}.$
A	a′	e	p	a″	e′	o.

2. *Native Amalgam.* (Fig. p. 392.)

41. The general form of this solid is a dodecahedron, with modified edges and solid angles.

E $= \infty O.$ a′$=2O2$, (§ 36, *e*, 2, fig. 18.)
p $= \infty O \infty$, faces of cube (fig. 6.) a$=O$ face of octahedron, (fig. 8.)
e′$= \infty On$, (fig. 13.) o $= mO\frac{m}{m-1}$, (§ 36, *e*, 1, fig. 27.)

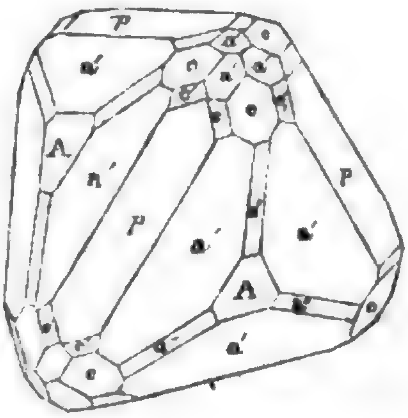
The inclination of e′ on p ($\infty O \infty$) $=161° 34'$; from which by subtracting 90°, we obtain 71° 34′, which is half the inclination of e′ on e′ over p, and, therefore, equals ν, (§ 39;) therefore, (§ 39, *d*, 1,) $n = \tan. \nu = \tan. 70° 34' = 3$. Consequently, e′ $= \infty O3$.

The determination also of o depends on measurement, and the process is the same as given in the remarks on red copper ore. By this means it is found that $O = 3O\frac{3}{2}$.

The expression for the crystal is, therefore,

$$\infty O.\ \ 2O2.\ \ 3O\tfrac{3}{2}.\ \ \infty O \infty.\ \ \infty O3.\ \ O.$$

Gray Copper Ore.



42. This solid has a hemihedral character, being a trigonal hemi-trisoctahedron, with replaced edges and angles. Its planes belong to the following forms :

A, a face of a tetrahedron, (fig. 35,) $= \frac{O}{2}$;
p, a face of a cube, $= \infty O \infty$;
a′ $= \frac{mOm}{2}$, (figs. 33, 34 ;)
e $= \infty O$, (fig. 36 ;)
e′$= \infty On'$, (fig. 38, § 37, *a*, 2 ;)
— a′ $= - \frac{m'Om'}{2}$;
a″$= \frac{m''O}{2}$, (fig. 37, § 37, *a*, 1.)

The intersections of a′ with two planes e (∞O) are parallel, and therefore, (§ 37, *a*, 3,) $m = 2$ and $\frac{mOm}{2} = \frac{2O2}{2}$.

For the same reason, — a′ $= - \frac{2O2}{2}$.

The planes a″ truncate the shorter edges of $\frac{2O2}{2}$, and, therefore, $a'' = \frac{\frac{3}{2}O}{2}$, (§ 37, *a*, 1.)

The edges e′ : a′ are parallel to the shorter edges of $\frac{2O2}{2}$, therefore, with respect to the plane e′, (§ 37, *a*, 2,) $n' = m+1$, and hence $e' = \infty O3$.

The collected signs are, $\frac{2O2}{2}$. $\infty O \infty$. ∞O. $\frac{O}{2}$. $-\frac{2O2}{2}$. $\infty O3$. $\frac{\frac{3}{2}O}{2}$.

Iron Pyrites. (Fig. 1, p. 406.)

43. The several forms contained in this crystal are as follow :

$P = \infty O \infty$, fig. 1.

$a = O$, fig. 2.

$a' = m''Om''$, fig. 14.

$o'' = \frac{[mOn]}{2}$.

$o' = \frac{[m'On']}{2}$.

$e' = \frac{[\infty On']}{2}$. fig. 42.

$e'' = \frac{[\infty On'']}{2}$.

By a measurement of e′ on P it is found as in § 41, $e' = \infty O\,2$. e′ ($\infty O2$) truncates the edge o″ : o″, that is, the longest edge of the parallel hemi-hexoctahedron o″; therefore, (§ 37, *b*, 5,) $n' = n = 2$ and $\frac{[m\,O\,n]}{2} = \frac{[m\,O\,2]}{2}$. But o″ makes parallel intersections with e′ and a′ and consequently by means of the general equation, § 28, for the parameter of a plane forming parallel intersections with two others, we find $o'' = \frac{[4\,O\,2]}{2}$.

In the same manner also, it is found that $a' = 2\,O\,2$, (§ 37, *b*, 8.)

In consequence of the parallelism of the intersections of o′ a′ and a″, the planes o′ replace the edges *C* (fig. 49) of the hemi-hexoctahedron o″, and are inclined on the longest edge *B*, (fig. 49 ;) and therefore (§ 37, *b*, 3) $n' = \frac{m'(m^2-n)\,n}{(mn-1)\,mn+m'(m-n^2)\,m}$. Substituting 4 for *m*, and 2 for *n*, and reducing the equation, we obtain $n' = \frac{1}{2}m'$.

If now the plane e′ were so extended as to form an edge with o′, this edge would be parallel to the intersection of o′ with a′ and from the parallelism of these two lines, observing that $a = O$, $e' = \infty O\,2$, it is determined that $n = \frac{2m}{m-1}$. By equating these two values of *m*, it is found that $m = 2$ and $n = \frac{3}{2}$ and the whole sign of o′ is $\frac{[3\,O\,\frac{3}{2}]}{2}$. Also from § 37, *b*, 5, $e'' = \frac{[\infty\,O\,\frac{3}{2}]}{2}$.

But as this intersection of e′ with o′ does not exist in the crystals, we must have recourse to a measurement. As above, we first ascertain by measurement that $e'' = \frac{[\infty O \frac{3}{2}]}{2}$. Consequently, (§ 37, *b*, 5,) $o'' = \frac{[3 O \frac{3}{2}]}{2}$.

The expression for the crystal is, therefore,

$$\infty O \infty. \quad \frac{[3 O \frac{3}{2}]}{2}. \quad \frac{[4 O 2]}{2}. \quad \frac{[\infty O 2]}{2}. \quad \frac{[\infty O \frac{3}{2}]}{2}. \quad O. \quad 2 O 2.$$

The following are the descriptive expressions of the figures on Plate I., belonging to the Class Monometrica:

1. $\infty O \infty$
2. $\infty O \infty. O.$
3. $O. \infty O \infty$
4. $O.$
5. $\infty O \infty. \infty O$
6. $\infty O. \infty O \infty$
7. ∞O
8. $\infty O. O$
9. $O. \infty O$
10. $\infty O \infty. \infty O n.$
11. $\infty O n.$
12. $O. \infty O 2$
13. $\infty O. \infty O n$
14. $\infty O \infty. 2 O 2$
15. $2 O 2. \infty O \infty$
16. $2 O 2$
17. $O. m O m.$
18. $\infty O. 2 O 2$
19. $\infty O \infty. 2 O$
20. $2 O$
21. $O. 2 O.$
22. $2 O. 2 O 2.$
23. $2 O. \infty O n.$
24. $\infty O \infty. m O n.$
25. $m O n$
26. $O. m O n.$
27. $\infty O. m O \frac{m}{m-1}.$
28. $\infty O \infty. \frac{O}{2}$
29. $\frac{O}{2}. \infty O \infty.$
30. $\frac{O}{2}.$
31. $-\frac{O}{2}.$
32. $\frac{O}{2}. -\frac{O}{2}$
33. $\infty O \infty. \frac{2 O 2}{2}.$
34. $\frac{2 O 2}{2}.$
35. $\frac{O}{2}. \frac{2 O 2}{2}$
36. $\frac{2 O 2}{2}. \infty O$
37. $\frac{2 O 2}{2}. \frac{\frac{3}{2} O}{2}.$
38. $\frac{2 O 2}{2}. \infty O 3.$
39. $\infty O \infty. \frac{2 O}{2}.$
40. $\frac{2 O}{2}.$
41. $\frac{m O n}{2}.$
42. $\infty O \infty. \frac{[\infty O n]}{2}.$
43. $\frac{[\infty O n]}{2}. \infty O \infty.$
44. $\frac{[\infty O n]}{2}$
45 and 46. $O. \frac{[\infty O 2]}{2}$
47 $\frac{[\infty O 2]}{2}. O$
48. $\infty O \infty. \frac{[m O n]}{2}.$
49. $\frac{[m O n]}{2}.$

CLASS DIMETRICA.

44. In the Class Dimetrica, the octahedron formed on the angles of the prism, (fig. 52,) proceeds from the ratio 1 : 1 : 1 ; or, calling the vertical axis *a*, its ratio is *a* : 1 : 1, and its sign is *P*. Other similar solids on the angles have the general sign *mP*, (fig. 57.) As the vertical axis of the terminal plane *P* may be supposed to = 0, this plane is crystallographically designated *oP*. The lateral planes have the usual sign $\infty P \infty$, since they are formed on the angles of the fundamental octahedron, and are parallel to two axes. The planes truncating the lateral edges, (fig. 61,) if situated on the octahedron, (fig. 52,) would truncate its basal edges. They therefore would intersect two lateral axes, and be parallel to the vertical, and hence are designated ∞P. The beveling planes e' (fig. 62) are also parallel to the vertical axis, and consequently, since they meet the lateral unequally, have the general sign $\infty P\ n$. Planes on the basal edges of the prism (fig. 53) are situated on the terminal edges of the octahedron, (fig. 55,) or replace the terminal or the lateral angles, (fig. 56;) and extended they would form octahedrons having the general sign $m\ P \infty$, since they are parallel to one lateral axis. The planes o in fig. 58, have the general sign $m\ P\ n$, and extended form the solid represented in fig. 59.

45. Hemihedral forms may arise in the same manner as in the monometric system, and are similarly designated. The tetrahedrons, fig. 63, *a*, *b*, are designated $+\frac{mP}{2}$ and $-\frac{mP}{2}$. The planes on fig. 66, extended, give rise to fig. 67, and are designated in general $\frac{mPn}{2}$.

Another kind of hemihedron may arise, when the left hand o at top, and the right at bottom, (see fig. 58,) or the right at top, and left at bottom of the two planes on each angle, occur alone. These are either $\frac{r}{l}\frac{mPn}{2}$ or $\frac{l}{r}\frac{mPn}{2}$. By left hand at bottom is understood, not what appears to be the left at bottom in fig. 58, but what would be to the left, if the crystal were inverted; that is, the face which in the present situation of the crystal is to the right at bottom.

A third kind is produced when the occurring plane o, is that to the right on each angle, or that to the left on each. These are expressed by the signs $r\frac{mPn}{2}$, $l\frac{mPn}{2}$.

I. CALCULATIONS OF THE INTERFACIAL ANGLES OF THE HOLOHEDRAL FORMS.

46. We first consider the octagonal pyramid mPn, fig. 59, taking as usual the most general case. The interfacial angles to be determined are X, Y, Z, or $F : F'$, $F : F''$, $F : F'''$. The equation of F is $\frac{x}{ma} + \frac{y}{n} + z = 1$, which gives for its parameter $m\ a$, n, 1, to be substituted in the general equation, § 19, for a, b, c. From

$$F' = \frac{x}{ma} - \frac{y}{n} + z = 1, \text{ we obtain } a' : b' : c' = ma : -n : 1.$$

$$F'' = \frac{x}{ma} + y + \frac{z}{n} = 1, \quad \text{“} \quad a' : b' : c' = ma : 1 : n.$$

$$F''' = \frac{x}{-ma} + \frac{y}{n} + z = 1, \quad \text{“} \quad a' : b' : c' = -ma : n : 1.$$

By a substitution of these in succession, we obtain for the interfacial angles,

$$\text{Cos. } X = -\frac{m^2 a^2 (n^2 - 1) + n^2}{m^2 a^2 (n^2 + 1) + n^2}.$$

$$\text{Cos. } Y = -\frac{n\,(2 m^2 a^2 + n)}{m^2 a^2 (n^2 + 1) + n^2}.$$

$$\text{Cos. } Z = -\frac{m^2 a^2 (n^2 + 1) - n^2}{m^2 a^2 (n^2 + 1) + n^2}.$$

In a similar manner we might obtain the angle of inclination, *T*, of two planes, over the axial angle of the base, and also the inclination *U*, of two planes, *F*, over the interaxial angle of the base, or that at the edge Y. Their tangents are,

$$\text{Tan. } \tfrac{1}{2}\, T = \frac{m\,a\,n}{\sqrt{(m^2 a^2 + n^2)}}. \qquad \text{Tan. } \tfrac{1}{2}\, U = \frac{m\,a\,(n+1)}{\sqrt{(m^2 a^2 (n-1)^2 + 2n^2)}}.$$

The cosines, signs, and tangents, of half the above angles, are as follow: *M* is written for $m^2a^2 (n^2 + 1) + n^2$.

	Cos.	Sin.	Tan.
Angle ½ *X*;	$-\frac{m\,a}{M}$	$-\frac{n\sqrt{(m^2a^2+1)}}{M}$	$-\frac{n\sqrt{(m^2a^2+1)}}{m\,a}$
Angle ½ Y;	$-\frac{m\,a\,(n-1)}{M\sqrt{2}}$	$-\frac{\sqrt{(m^2a^2(m+1)^2+2n^2)}}{M\sqrt{2}}$	$-\frac{\sqrt{(m^2a^2(n+1)^2+2n^2)}}{m\,a\,(n-1)}$
Angle ½ *Z*;	$-\frac{n}{M}$	$-\frac{ma\sqrt{(n^2+1)}}{M}$	$-\frac{ma\sqrt{(n^2+1)}}{n}$

From the above we deduce

$$\text{Cos. } \tfrac{1}{2}\, X : \text{cos. } \tfrac{1}{2}\, Z :: ma : n.$$
$$\text{Cos. } \tfrac{1}{2}\, Y : \text{cos. } \tfrac{1}{2}\, Z :: ma\,(n-1) : n\sqrt{2}.$$
$$\text{Cos. } \tfrac{1}{2}\, X : \text{cos. } \tfrac{1}{2}\, Y :: \sqrt{2} :: n-1.$$

The corresponding proportions for the other dimetric forms are,

	Cos. ½ *X* : cos. ½ *Z*.	Cos. ½ Y : cos. ½ *Z*.	Cos. ½ *X* : cos. ½ Y.
mPm	$a : 1$	$a(m-1) : \sqrt{2}$	$\sqrt{2} : m-1.$
$mP\frac{m}{m-1}$	$a(m-1) : 1$	$a : \sqrt{2}$	$(m-1)\sqrt{2} : 1.$
mP	$ma : 1$		
$mP\infty$		$ma : \sqrt{2}$	

II. DETERMINATION OF m AND n FROM THE INTERFACIAL ANGLES.

47. Let $\nu' =$ half the inclination of edge *X* on the base of the octagonal pyramid; $\delta' =$ half the inclination of edge Y on the base of the octagonal pyramid; $\nu =$ half the angle of the base, which edge *X* meets; $\delta =$ half the angle of the base, which edge Y meets.

The following equations will then obtain. Their demonstrations are not given, as they are deduced without difficulty.

$$\text{Tan. } \nu \text{ (angle } X \text{ of } \infty On) = n.$$

$$\text{Tan. } \delta \text{ (angle } Y \text{ of } \infty On) = \frac{n+1}{n-1}.$$

$$\text{Tan. } \nu' = ma.$$

$$\text{Tan. } \delta' = \frac{ma(n+1)}{n\sqrt{2}}.$$

1. If X and Z be given in the form mPm, we deduce from the values of their sines and cosines,

$$\frac{\cos. \frac{1}{2} X}{\sin. \frac{1}{2} Z} = \frac{1}{\sqrt{(n^2+1)}}.$$

But since $n = \tan. \nu$, we find by trigonometry, $\frac{1}{\sqrt{(n^2+1)}} = \cos. \nu$. Therefore, $\frac{\cos. \frac{1}{2} X}{\sin. \frac{1}{2} Z} = \cos. \nu$. n may then be found by the equation, $\tan. \nu = n$.

In a manner similar to the above, we find $\frac{\cos. \frac{1}{2} Z}{\sin. \frac{1}{2} X} = \cos. \nu'$; and thence for ma, $\tan. \nu' = ma$.

2. If Y and Z be given, we find as above,

$$\frac{\cos. \frac{1}{2} Y}{\sin. \frac{1}{2} Z} = \cos. \delta.$$

Then since $\nu = 180° - (\delta + 45°,)$ $\tan. (\delta + 45°) = n$.

Again, $\frac{\cos. \frac{1}{2} Z}{\sin. \frac{1}{2} Y} = \cos. \delta'$; $ma = \frac{n\sqrt{2}}{n+1} \tan. \delta'$.

3. If X and Y be given:

$$\frac{\cos. \frac{1}{2} Y \sqrt{2}}{\cos. \frac{1}{2} X} = n - 1.$$

From the value of tan. X, we find

$$ma = \frac{n}{\sqrt{(\tan.^2 \frac{1}{2} X - n^2)}}.$$

48. The corresponding equations for the other dimetric forms may be derived from observing, that for mPm, $a \cos. \frac{1}{2} Z = \cos. \frac{1}{2} X$, (§ 46,) for $mP\frac{m}{m-1}$, $a \cos. \frac{1}{2} Z = \cos. \frac{1}{2} Y \sqrt{2}$, &c.

a. mPm.

1. From X, $\cos. \nu' = \frac{1}{a} \cot. \frac{1}{2} X$; $ma = \tan. \nu'$.

2. From Z, $\cos. \nu = a \cos. \frac{1}{2} Z$; $m = \tan \nu$.

3. From T, $m = \frac{\tan. \frac{1}{2} T \sqrt{(a^2+1)}}{a}$.

If T' of the fundamental pyramid is known, since $\tan. \frac{1}{2} T^{v} = \frac{a}{\sqrt{(a^2+1)}}$, (deduced from tan. $\frac{1}{2}$ T, § 46, by making $n = m = 1$,) we have $m = \tan. \frac{1}{2} T \times \cot. \frac{1}{2} T^{v}$.

$b.\ mP\frac{m}{m-1}$.

1. From Y: $\cos.\ \delta' = \frac{1}{a}\cot.\ \frac{1}{2}Y\sqrt{2}$; $2m-1 = \frac{1}{a}\tan.\ \delta'\sqrt{2}$.

2. From Z: $\cos.\ \delta = a\sqrt{\frac{1}{2}}\cot.\ \frac{1}{2}Z$; $\frac{m}{m-1} = \tan.\ (\delta + 45°.)$

3. From U: $2m-1 = \frac{\sqrt{(a^2+2)}\times\tan.\frac{1}{2}U}{a}$, or if the angle U' of the pyramid $P\infty$ is known, since $\tan.\ \frac{1}{2}U' = \frac{a}{\sqrt{(a^2+2)}}$, (deduced from the value of $\tan.\ \frac{1}{2}U$, § 46, by making $n = \frac{m}{m-1}$,) $2m-1 = \tan.\ \frac{1}{2}U \times \cot.\ \frac{1}{2}U'$.

$c.\ mP$.

1. From X: $ma = \cot.\ \varepsilon$; $\cos.\ \varepsilon = \cot.\ \frac{1}{2}X$.
2. From Z: $ma = \tan.\ \frac{1}{2}Z\sqrt{\frac{1}{2}}$, $m = \frac{\tan.\frac{1}{2}Z}{\tan.\frac{1}{2}Z'}$; Z' being the corresponding angle of the fundamental form.

$d.\ mP\infty$.

1. From Y: $ma = \cot.\ \varepsilon$; $\cos.\ \varepsilon = \cos.\ \frac{1}{2}Y\sqrt{2}$.
2. From Z: $ma = \tan.\ \frac{1}{2}Z$; $m = \frac{\tan.\frac{1}{2}Z}{\tan.\frac{1}{2}Z'}$.

$e.\ \infty Pn$.

1. From X: $n = \tan.\ \frac{1}{2}X$.
2. From Y: $\frac{n+1}{n-1} = \tan.\ \frac{1}{2}Y$.

III. CALCULATIONS OF THE INTERFACIAL ANGLES OF THE HEMIHEDRAL DIMETRIC SOLIDS.

49. By substituting the parameters of the faces in the general equation for the cosines of interfacial angles, we obtain for $\frac{mPn}{2}$, (fig. 67,)

$$\text{Cos. } X = -\frac{n(2m^2a^2-n)}{m^2a^2(n^2+1)+n^2}.$$

$$\text{Cos. } Y = -\frac{n(2m^2a^2+n)}{m^2a^2(n^2+1)+n^2} = \text{cos. } Y, \text{ (§ 46.)}$$

$$\text{Cos. } Z = -\frac{m^2a^2(n^2-1)-n^2}{m^2a^2(n^2+1)+n^2} = \text{cos. } Z, \text{ (§ 46.)}$$

The cosines of the semiangles are,

$$\text{Cos. } \tfrac{1}{2}X = \frac{ma(n+1)}{M\sqrt{2}}, \qquad \text{Cos. } \tfrac{1}{2}Y = \frac{ma(n-1)}{M\sqrt{2}};$$

and hence we obtain the proportion,

$$n = \frac{\cos.\frac{1}{2}X + \cos.\frac{1}{2}Y}{\cos.\frac{1}{2}X - \cos.\frac{1}{2}Y}.$$

If $n=1$, as in $\frac{mP}{2}$, we obtain,

$$\text{Cos. } X = -\frac{2m^2a^2-1}{2m^2a^2+1}. \quad \text{Cos. } Y = -1. \quad \text{Cos. } Z = -\frac{1}{2m^2a^2+1}.$$

IV. COMBINATIONS OF THE DIMETRIC FORMS AND THE DETERMINATION OF THE SIGNS OF PLANES BY INSPECTION.

1. *Holohedral.*

50. The following general laws are obvious deductions from what has already been explained.

1. Forms whose intersections are horizontal and parallel, have $n'=n$, (fig. 57, a′, a, a″.)

2. Forms which have their intersections parallel, and also parallel to the edge x, have $m'=m$, (c and a, fig. 55; o, fig. 60.)

The following deduced formulas have been obtained in the same manner as those for the monometric solids:—

a. Combinations of *mPn*, (fig. 59.)

$m'P$	1. Trunc. of edge Y of mPn,	$m'=\frac{m(n+1)}{2n}$
	2. Rep. of Term-A. by 4 rbc. pl. inc. on edge Y,	$m'=\frac{m}{n}$
	3. Rep. of basal angle at Y by 2 pl. inc. on Y. I-E. par. to X, (fig. 60,)	$m'=m$
$m'P\infty$	4. Trunc. of X,	$m'=m$
	5. Rep. of Term-A. by 4 rbc. pl. inc. on X,	$m'=\frac{m(n-1)}{n}$.
	6. Rep. of Basal A. at X by 2 pl. inc. on X. I-E. par. to Y,	$m'=\frac{m(n+1)}{n}$
$\infty Pn'$	7. Trunc. of basal edge,	$n'=n$

b. *mP*, (fig. 52.)

$m'Pn'$	1. Bev. of Term-E. of mP, (fig. 60,)	$m'=m$
$m'P\infty$	2. Rep of Basal E. by 4 pl. I-E. par. to term. edges,	$\frac{m'}{n'}=m$
	3. Trunc. of Term-E. (fig. 55,)	$m'=m$
	4. Rep. of Basal A. by 2 pl. inc. on Term-E. I-E. of two pl. with the same face of mP, parallel, (fig. 56,)	$m'=2m$

c. *mP* ∞.

$m'Pn'$	1. Bev. of Term-Edges of $mP\infty$, (sim. to fig. 60,)	$m=\frac{m'(n'+1)}{n'}$
$m'P$	2. Rep. of Basal A. by 2 pl. inc. on Term-E. I-E. of two planes with the same face of $mP\infty$ parallel, (sim. fig. 56,)	$m'=m$
	3. Trunc. of Term-E. of $mP\infty$, (fig. 55,)	$m'=\frac{1}{2}m$
$m'P\infty$	4. Bev. of Basal Edges of $mP\infty$, or rep. of Term-A. by 4 pl. with horizontal intersections, (sim. fig. 57.)	

51.—2. *Hemihedral.*

a. Combinations of $\frac{mP}{2}$, (fig. 63.)

$\pm\frac{m'Pn'}{2}$	1. Bev. of middle edges, (fig. 64,)	$\frac{m'}{n'}=m$
$-\frac{m'P}{2}$	2. Rep. of angles by a pl. with I-E. par. to middle edges of $\frac{mP}{2}$,	$m'=m$
$m'P\infty$	3. Rep. of ang. by 2 pl. I-E. of two pl. with the same face of $\frac{mP}{2}$ parallel,	$m'=2m$
∞P	4. Rep. of angles.	
$\infty P\infty$	5. Rep. of middle edges, (fig. 65.)	

b. $mP\infty$.

$\pm\frac{m'Pn'}{2}$	1. Bev. of alternate Term-E. (fig. 68,)	$m=\frac{m'(n+1)}{n'}$
$\pm\frac{m'P}{2}$	2 Trunc. of alternate Term-E.,*	$m'=\frac{1}{2}m$

V. CALCULATION OF THE INTERFACIAL ANGLES BETWEEN THE DIFFERENT DIMETRIC FORMS IN COMBINATION.

52. By substituting the parameters of the faces in the general equation for the cosines of interfacial angles, the cosine of the inclination of two faces of mPn and $m'Pn'$, is determined to be as follows:—

$$\text{Cos. } Q=\frac{mm'a^2(nn'+1)+nn'}{\sqrt{[m'a^2(n^2+1)+n^2]}\sqrt{[m'^2a^2(n'^2+1)+n'^2]}}.$$

By a substitution of the several values which m and n may have, we obtain the sought angles. The following table contains a few simplified formula for the more simple forms. In it, $M=\sqrt{(m^2a^2(n^2+1)+n^2}$.)

	oP	$\infty P\infty$	$\infty Pn'$	$m'P\infty$
mPn	$\frac{n}{M}$	$\frac{mna}{M}$	$\frac{ma(nn'+1)}{M\sqrt{[n'^2+1]}}$	$\frac{(mm'a^2+1)n}{M\sqrt{[m'^2a^2+1]}}$
mP	$\sqrt{[2m^2a^2+1]}$	$\frac{ma}{\sqrt{[2m^2a^2+1]}}$	$\frac{ma(n^2+1)}{\sqrt{[2m^2a^2+1]}\sqrt{[n'^2+1]}}$	$\frac{mm'a^2+1}{\sqrt{[2m^2a^2+1]}\sqrt{[m'^2a^2+1]}}$
$mP\infty$	$\sqrt{[m^2a^2+1]}$	$\frac{ma}{\sqrt{[m^2a^2+1]}}$	$\frac{mn'a}{\sqrt{[m^2a^2+1]}\sqrt{[n'^2+1]}}$	$\frac{mm'a^2+1}{\sqrt{[m^2a^2+1]}\sqrt{[m'^2a^2+1]}}$
∞Pn		$\frac{n}{\sqrt{[n^2+1]}}$	$\frac{nn'+1}{\sqrt{[n^2+1+]}\sqrt{[n'^2+1]}}$	

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* The following abbreviations have been used above, in addition to those explained under the Class Monometrica: *Term-E.*, terminal edge; *Term-A.*, terminal angle; *A.* or *Ang.*, angle.

VI. EXAMPLES ILLUSTRATIVE OF THE METHOD OF DETERMINING THE CRYSTALLOGRAPHIC SIGNS OF PLANES IN THE DIMETRIC SYSTEM.

Anatase, (figure, p. 361.)

53. This crystal is an octahedron, with truncated edges and replaced angles. The axis a of the fundamental form $A=P,= \frac{\sqrt{25}}{8}$, cos. $Z=\frac{21}{29}$, tan. $\frac{1}{2}Z=\frac{5}{2}$, and $Z=136° 24'$.

$$P=0P, \qquad M=\infty P,$$
$$\mathrm{e}=P\infty, \text{ (§ 50, 2, fig. 55.)}$$

The intersections of two planes e″ with the same a are parallel, and consequently, $\mathrm{e}''=2P\infty$, (§ 50, b, 4.)

a′ on $A=253° 27'$, the supplement of which, $26° 33'=\frac{1}{2}Z$. From formula (§ 48, c, 2) $m=\frac{\tan.\frac{1}{2}Z}{\tan.\frac{1}{2}Z'}$, we find $\mathrm{a}'=\frac{1}{3}P$.

Consequently, $\mathrm{e}'=\frac{1}{3}P\infty$, (§ 50, 2.)

Description of the crystal, $P.\ \infty P.\ 2P\infty.\ P\infty.\ \frac{1}{3}P.\ \frac{1}{3}P\infty.\ 0P.$

Idocrase, (fig. 3, p. 350.)

54. a, a, are faces of the fundamental octahedron.

Axis $a=\sqrt{\frac{2}{7}}$. Consequently, cos. $X=-\frac{3}{11}$, cos. $Y=-\frac{7}{11}$.
$X=129° 31'$, and $Z=74° 10\frac{1}{2}'$.

It is obvious, that

$$P=0P,\ e=\infty P,\ M=\infty P\infty,\ \mathrm{e}=P\infty, \text{ (§ 50, 2.)}$$

An approximative measurement gives the angle $\mathrm{a}' : e=146° 30'$, from which, if 90° be subtracted, we obtain $56° 30'=\frac{1}{2}Z$, and since

$$m=\frac{\cos.\frac{1}{2}Z}{\cos.\frac{1}{2}Z'},\ =\frac{\tan. 56° 30'}{\tan. 37° 5'}=2 : \text{therefore, } \mathrm{a}'=2P.$$

The planes e'', e', are of the general form ∞Pn. By measurement we find, $M : e''=153° 30'$, $M : e'=161° 34'$. Subtracting 90°, there remains the value of $\frac{1}{2}X$ for each form; and since $m=\tan.\frac{1}{2}X$, (§ 48, f, 1,) $e''=\infty P2$, $e'=\infty P3$.

Because the planes o', o^{iv}, and e'', have horizontal intersections, and $e''=\infty P2$, both o' and o^{iv} are of the form $mP2$, (§ 50, 1.) Because also o^{iv} forms parallel intersections with M and a′, ($2P$,) $\mathrm{o}^{\mathrm{iv}}=4P2$. Also, o′, o″, o‴, form parallel edges between M and a, and are, therefore, of the general form mPm, (§ 50, b, 2.) Consequently, from the above, $\mathrm{o}'=2P2$. As the mutual intersections of a″, o^{iv}, o‴, are parallel to one another, and also to the normal section, $m'=m$, (§ 50, 2,) and since $\mathrm{o}^{\mathrm{iv}}=4P2$, $\mathrm{o}'''=4P4$, and $\mathrm{a}''=4P$.

The planes o^{v} replace the basal angles of the pyramid P, and their edges of intersection with the same a are parallel; therefore, (§ 50, a, 1,) $m(n+1)=2m'n$; or since $m'=1$,

$$m(n+1)=2n.$$

Again, since o^{v} replaces the edge between e ($P\infty$) and o', ($2P2$,)

$$m(n-1)=n, \text{ (§ 29, } c, \text{ 2.)}$$

Therefore, $m(n+1)=2m(n-1) \therefore n=3$ and $o^{v}=\frac{3}{2}P3$.

Since the intersection of o^{v} and o'' are horizontal, $n'=n$, and consequently, $o''=3P3$.

To determine o' by measurement, we measure the angle $o':M$, from which, by subtracting 90°, we obtain $\frac{1}{2}T$. Then by formula, (§ 48, a, 3,) $m=\tan.\ \frac{1}{2}T\times\cot.\ \frac{1}{2}T^{v}$, we determine m, as before, equal to 2.

The signs of the crystal thus developed are,
$\infty P\infty$. P. $0P$. ∞P. $2P$. $4P$. $2P2$. $4P2$. $P\infty$. $\frac{3}{2}P3$. $\infty P3$. $\infty P2$. $3P3$. $4P4$.

Tungstate of Lime, (figure, p. 208.)

55. This crystal contains two instances of hemihedral planes, plane o', ${}^{r}_{l}\frac{mPn}{2}$, and plane o'', ${}^{l}_{r}\frac{mPn}{2}$. The faces of the fundamental pyramid are a, and the length of its axis, according to Levy, is $\sqrt{\frac{11}{16}}$. Therefore, $X=108°\ 12'$, and $Z=112°\ 2'$.

The edge $A:e'$ is parallel to a perpendicular drawn from the vertex to the base of A. Consequently, $e'=2P\infty$, (§ 50, b, 4.)

Since o'' replaces the edge $e':A$, $m+mn-2n=0$, (§ 29, d, 1.) Consequently, $m=\frac{2n}{n+1}$. The inclination $e':o''=163°$ nearly. The supplement of this angle, added to half the interfacial angle at the terminal edge of e', (50° 20′,) gives for $\frac{1}{2}$ Y, 67° 20′.

Substituting in the value of $\tan.\ \frac{1}{2}$ Y, (§ 46,) $\frac{2n}{n+1}$ for m, we obtain $\tan.\ \frac{1}{2}\text{Y}=\frac{n+1}{n-1}\sqrt{\frac{16}{11}}$.

Whence it is found that $n=3$, and consequently $m=\frac{3}{2}$, and the sign is ${}^{l}_{r}\frac{\frac{3}{2}P3}{2}$.

The intersections o'', e, o', being parallel, we find for o' by equation, § 28, $m=\frac{m}{m-2}$. The interfacial angle $a:o'=151°\ 33'$. Subtracting the supplement of this angle from the terminal interfacial angle of $2P\infty$, we find $\frac{1}{2}X=21°\ 53'$, from which, as above, we obtain $o'={}^{r}_{l}\frac{4P2}{2}$.

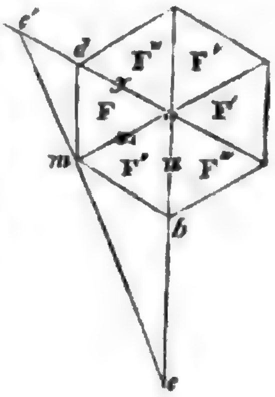
Description of the crystal, P, $2P\infty$, ${}^{l}_{r}\frac{\frac{3}{2}P2}{2}$, ${}^{r}_{l}\frac{4P2}{2}$.

The following are the descriptive expressions of the figures on Pl. I., belonging to Class Dimetrica:

50. $0P.\infty P\infty$.
51. $0P.P.\infty P\infty$.
52. P.
53. $0P.mP\infty.\infty$.
54. $mP\infty.\infty P\infty$.
55. $mP.mP\infty$
56. $mP.2mP\infty$.
57. $mP.m''P.m'P$.
58. $0P.mPn.\infty P\infty$.
59. mPn.
60. $mPn.mP.\frac{m}{n}P$.
61. $0P.\infty P.\infty P\infty$.
62. $0P.\infty Pn.\infty P\infty$.
63. $+\frac{P}{2}$.
64. $-\frac{P}{2}$.
65. $\frac{P}{2}.nPn$.
66. $\frac{P}{2}.\infty P\infty$.
67. $0P.\frac{mPn}{2}$.
68. $\frac{mPn}{2}$.
69. $mP\infty.\frac{m'Pn}{2}$.

CLASS TETRAXONA.

56. The fundamental form, or that which proceeds from the simple ratio $a:1:1$, is represented in fig. 124, Pl. II. It proceeds from a hexagonal prism, by a replacement of its basal edges or angles.



For the purposes of calculation, the vertical axis is designated the *axis of x*, and the lateral respectively axes of y, z, u. If one half of either of these axes (for instance, the part lettered) is assumed as positive, the other will be negative. The general equation of a plane F meeting the lateral axes y, z, and the positive or negative (that is, upper or under) portion of the vertical axis is

$$\pm\frac{x}{m}+\frac{y}{n}+\frac{z}{n}=1.$$

The equations of the other faces are,

For $F^{\prime}$, $\pm\frac{x}{m'}-\frac{y}{n'}-\frac{z}{r'}=1$. For $F^{\prime\prime}$, $\pm\frac{x}{m'}+\frac{u}{s'}+\frac{z}{r'}=1$.

$F^{\prime\prime\prime}$, $\pm\frac{x}{m'}+\frac{y}{n'}-\frac{u}{s'}=1$. F^{iv}, $\pm\frac{x}{m'}-\frac{y}{n'}+\frac{u}{s'}=1$.

F^{v}, $\pm\frac{x}{m'}-\frac{u}{s'}-\frac{z}{r'}=1$.

In the application of Analytical Geometry, two only of the three lateral axes are required. Assuming z and y as these two, every plane that may occur in this class, except those parallel to these axes, will intersect one or both of them. Therefore the situation of a plane may be accurately defined by a reference to these two lateral axes merely. These axes intersect at angles of 60° and 120°.

Since, then, we would substitute *y* or *z* for *u*, it will be necessary to determine where a plane, as *cm*, intersecting *u* at a certain distance from the centre, would intersect *y* or *z*; or in the figure, where *cm* would meet *y*, that is, the length of the line *ac'*.

From the similar triangles *cbm*, *cac'*, $ca : cb :: ac' : bm$. But $ca = s'$, the parameter of *u*; $bm = am = r'$, parameter of *z*; $cb = ca - ba = s' - r'$. Therefore $s' : s' - r' :: ac' : r' \therefore ac' = \frac{s'r'}{s'-r'}$.

It may be found in a similar manner, that a plane intersecting the axes *u* and *y*, if referred to *y* and *z*, would have $ac' = \frac{s'n'}{s'-n'} = 1$.

The equations for F'', F''', F^{iv}, F^{v}, above given, transformed by a substitution of these values, become,

$$\text{For } F'' \pm \frac{x}{m'} + \frac{(s'-r')y}{s'r'} + \frac{z}{r'} = 1. \qquad F''' \pm \frac{x}{m'} + \frac{y}{n'} + \frac{(s'-n')z}{s'n'}.$$

$$F^{\text{iv}} \pm \frac{x}{m'} - \frac{y}{n'} - \frac{(s'-n')z}{s'n'} = 1. \qquad F^{\text{v}} \pm \frac{x}{m'} - \frac{(s'-r')y}{s'r'} - \frac{z}{r'} = 1.$$

I. CRYSTALLOGRAPHIC SIGNS OF PLANES.

a. Holohedral Forms.

57. By a bevelment of the basal edges of the fundamental form, and by a replacement of its terminal solid angles, various forms *mP* may result. A truncation of the terminal solid angle is designated as in the preceding class, $0P$, and a truncation of the basal edges, $\infty P \infty$.

A truncation of the terminal edges produces another hexagonal pyramid, having a diagonal position relatively to the fundamental form. From the last figure it is apparent that a plane truncating a terminal edge, would meet the axes *y* and *u* at twice the distance from the centre that it would meet *z*. This is rendered apparent by drawing a line from *b* to *d*, which would intersect *y* and *u* at twice the distance from *a*, that it intersected *z*. The sign of this diagonal pyramid will therefore be *P*2, or in more general terms, *mP*2. A truncation of the basal edges produces a solid, with an infinite vertical axis, the prism $\infty P2$.

Intermediate forms in this class, are designated generally *mPn*; and if prisms, ∞Pn.

b. Hemihedral Forms.

A rhombohedron is *crystallographically* a hemihedral solid. It may result from the suppression of one half the faces of the fundamental form, viz. three alternate at one end, and those alternate with these, at the other. Or it may proceed from the hexagonal prism by a replacement, similarly alternate, of its basal edges or angles. The sign of a face of the rhombohedron is $\pm\frac{mP}{2}$. Similarly the form mPn may have the hemihedrons $\pm\frac{mPn}{2}$. When $n = 2$, the hemihedron has a diagonal position relatively to the rhombohedron, and is a scalene dodecahedron, (fig. 116.)

${}^{r}_{l}\frac{mPn}{2}$, ${}^{l}_{r}\frac{mPn}{2}$, and $r\frac{mPn}{2}$, $l\frac{mPn}{2}$, are signs of planes analogous in their derivation to those of similar signs in the Class Dimetrica. The holohedral forms mPn, if situated on the basal angles of the fundamental form, replace each, by four planes. In the various hemihedral forms, only one half of these four occur. In the forms $\pm\frac{mPn}{2}$, the occurring planes are the two upper of one angle, and the two lower of the next. Again, they may be the right (or left) hand plane above, and that which *will be to the right* (or left) of the part now below, when the crystal is inverted. These have the general designation $r\frac{mPn}{2}$, $l\frac{mPn}{2}$. Finally, the two right hand (or left) planes of each angle may be the occurring planes: if the crystal be inverted, the same planes will be to the left, (or right.) Their general designation is ${}^{r}_{l}\frac{mPn}{2}$, ${}^{l}_{r}\frac{mPn}{2}$.

c. *Tetartohedral Forms.*

The tetartohedral or *quarter* modifications of crystals, are instances of the occurrence of only one out of the four planes referred to in the last paragraph. These are in fact instances of hemihedrism on the rhombohedron, (§ 45.) But *crystallographically* the rhombohedron is hemihedral, and consequently these forms are tetartohedral.

If the existing plane is the right (or left) above of one angle of the fundamental pyramid, and the right (or left) below of the next, the same planes, when the crystal is inverted, will be to the left (or right) hand. Their sign is therefore in general similar to ${}^{l}_{r}\frac{mPn}{4}$, or ${}^{r}_{l}\frac{mPn}{4}$.

If the occurring plane is the right above, of one angle, and the left below of the next, &c. their sign will be, $\pm r\frac{mPn}{4}$, or $\pm l\frac{mPn}{4}$.

II. GENERAL REMARKS ON THE AXES AND EQUATIONS OF THE RHOMBOHEDRONS.

58. The general equation of a plane F in a rhombohedron Pm, is $\frac{x}{ma} + y + z = 1$, (1.) By varying the signs of x, y, z, u, the equations for the two other upper faces, and their opposites below, are found to be as follow:

$$\textit{Upper}, \ \frac{x}{ma} - y + u = 1. \ (2.) \qquad \frac{x}{ma} - z - u = 1. \ (3.)$$

$$\textit{Under}, -\frac{x}{ma} + z + u = 1. \ (4.) \qquad -\frac{x}{ma} + y - u = 1. \ (5.)$$

Since the coördinates of three planes are identical at their intersection, or the vertex of the solid angle they form, we may obtain the values of the coördinates of this angular point, by comparing and combining the above equations.

From eq. 1, $y = 1 - z - \frac{x}{ma}$; from eq. 2, $y = \frac{x}{ma} + u - 1$,

$\therefore \frac{x}{ma} + u - 1 = 1 - z - \frac{x}{ma}$; and consequently, $\frac{2x}{ma} + u + z = 2$. (6.)

Again, from eq. 4, $u = 1 - z + \frac{x}{ma}$; from eq. 6, $u = 2 - z - \frac{2x}{ma}$,

$\therefore 1 - z - \frac{x}{ma} = 2 - z - \frac{2x}{ma}$; and consequently, $\frac{3x}{ma} = 1$.

Whence is deduced, $x = \frac{1}{3} ma$.

Hence for the fundamental rhombohedron, in which $m = 1$, $x = \frac{1}{3} a$.

In a similar manner we find $y = -\frac{2}{3}$, $z = \frac{1}{3}$.

Also for the other lateral angles, $x = \frac{1}{3} ma$, $y = \frac{1}{3}$, $z = -\frac{2}{3}$.

The coördinates of the apex of the vertical angle, since its apex is in the axis of x, are, $x = ma$, $y = 0$, $z = 0$.

From the equations of the angular points of the vertical and lateral solid angles, the length of the inclined diagonal, or a line connecting these angles, may be obtained by means of the equation $D = \sqrt{(x-x)^2 + (y-y)^2 + (z-z)^2}$, and thus determined, it is found equal to $\frac{2}{3} \sqrt{m^2a^2+3}$, or if $m = 1$, it equals $\frac{2}{3} \sqrt{a^2+3}$.

III. SECONDARY NOTATION OF THE RHOMBOHEDRON.

59. *a.* A more simple method of notation for the rhombohedron, than that derived from its relation to the fundamental pyramid, has been generally adopted. According to it, mR is written for $\frac{mP}{2}$, ∞R for $\frac{\infty P}{2}$, &c.; and as the rhombohedral forms in this class are by far the most numerous, this method of expression is much the most convenient.

b. The same system of notation may be extended to the scalene dodecahedron, or scalenohedron, by comparing the lengths of the vertical axis of this solid, with that of the inscribed rhombohedron. Since a scalenohedron results from a bevelment of the lateral edges of a rhombohedron, an inscribed rhombohedron has its lateral edges in contact with the same edges of the former solid, and consequently their bases are coincident.

To determine the desired relation, we may find the coördinates of the vertex of the lateral angles of the scalenohedron, from the equations of its planes; and since this vertex is coincident with that of the same angle in the rhombohedron, the sought relation may be obtained by comparing the result thus found, with the above values of the rhombohedral lateral angles.

The equations of two planes of a scalenohedron in the same sextant, are,

$$\frac{x}{ma} + \frac{y}{n} + z = 1. \ (1.) \qquad \frac{x}{ma} + y + \frac{z}{n} = 1. \ (2.)$$

Those of the lower pyramid forming intersections with these,

$$-\frac{z}{ma} + z + \frac{u}{n} = 1; \qquad -\frac{x}{ma} + y - \frac{u}{n} = 1;$$

which transformed by a substitution of the value of u found in § 56, become

$$-\frac{x}{ma} + \frac{(n-1)y}{n} + z = 1. \ (3.) \qquad -\frac{x}{ma} + y + \frac{(n-1)z}{n} = 1. \ (4.)$$

From these equations, the terminal edge between 1 and 2 is found to have the equations

$$\frac{x}{ma} + \frac{n+1}{n} z = 1, \text{ and } y - z = 0,$$

and the edge between 3 and 4,

$$-\frac{x}{ma} + \frac{(2n-1)z}{n} = 1, \text{ and } y - z = 0.$$

The intersection of these lines is in the vertex of the solid angle; hence by combining them we obtain for the coördinates of this point,

$$-x = \frac{ma(2-n)}{3n}, \text{ or } -3x = \frac{ma(2-n)}{n}; \text{ also } y = z = \frac{2}{3}.$$

Now since x is also a coördinate of the same angular point in the rhombohedron, and equals $\frac{1}{3}$ *ma* or $\frac{1}{3}$ of the semiaxis, (that is, $3x =$ semiaxis,) we also have $\frac{ma(2-n)}{n} = 3x =$ semiaxis of rhombohedron. And as $\frac{ma(2-n)}{n} = \frac{m(2-n)a}{n}$, $\frac{m(2-n)}{n}$ is the coëfficient of the vertical axis a. The sign of the rhombohedron derived from the scalenohedron $\frac{mPn}{2}$ is therefore $\frac{m(2-n)}{n} R$.

60. If we multiply $\frac{ma(2-n)}{n}$, the length of the semiaxis of R, by $\frac{n}{2-n}$, we obtain as the product ma, which is the semiaxis of the scalenohedron. Consequently, by writing this fraction after R in the form of an index, we obtain a secondary sign for the scalenohedron, namely,

$$\frac{m(2-n)}{n} R^{\frac{n}{2-n}},$$

which may be deduced from the other sign $\frac{mPn}{2}$, by substituting in the above expression the numerical values of m and n from mPn.

From $\frac{3P\frac{3}{2}}{2}$ we deduce as a secondary sign, $\frac{3(2-\frac{3}{2})}{\frac{3}{2}} R^{\frac{\frac{3}{2}}{2-\frac{3}{2}}} = R^3$, the sought sign.

We may also derive the primary signs from the secondary $m'R^{n'}$. From the above secondary expression, $n' = \frac{n}{2-n}$,

therefore, $2n' - n'=n$, and consequently, $n = \frac{2n'}{n'+1}$.

Again, to determine m, $m' = \frac{m(2-n)}{n}$,

$\therefore m'n = 2m - mn$, and $m = \frac{m'n}{2-n}$; but since $\frac{n}{2-n} = n'$,

$m = m'n'$.

Consequently, $m'n' P^{\frac{2n'}{n'+1}}$ is the primary sign of the scalenohedron, $m'R^{n'}$. From R^3 we obtain $3P^{\frac{2\cdot 3}{3+1}} = 3P^{\frac{3}{2}}$, as above.

In the diagonal prism, arising from the truncation of the lateral edges of the rhombohedron, the vertical axis $= \infty$, and consequently, mR^n becomes mR^∞. This sign is equivalent to $\infty P2$, which is the primary sign of the same.

In recapitulation we state, that for any rhombohedron, we have the general expression, mR.

For a series of scalenohedrons arising from a bevelment of the lateral edges of any rhombohedron, mR, the general expression is

$$mR^n;$$

and for the prism, (or scalenohedron with an infinite axis,)

$$mR^\infty.$$

IV. CALCULATION OF INTERFACIAL ANGLES.

1. *Holohedral Forms.*

61. The lateral axes are obliquely inclined, and require the equation for cos. W, in § 25. Since the angle of inclination is 60°, and

cos. $60° = \frac{1}{2}$, and sin.^{2} $60° = \frac{3}{4}$, the equation becomes, after a substitution of these values,

$$\text{Cos. } W = \frac{2mm'(2nn'+2rr'-n'r-nr')+3nrn'r'}{\sqrt{(4m^2(n^2-nr+r^2)+3n^2r^2)}\times\sqrt{(4m'^2(n'^2-n'r'+r'^2)+3n'^2r'^2)}}.$$

a. Form mPn, (fig. 126.)

The equation of F, of this solid, is $\frac{x}{ma}+\frac{y}{n}+z=1$.

The equation of F^{v}, $\frac{x}{ma}+\frac{n-1}{n}y+z=1$.

$$F^{v\prime},\ \frac{x}{ma}+y+\frac{z}{n}=1.$$

$$F^{v\prime\prime},\ -\frac{x}{ma}+\frac{y}{n}+z=1.$$

Substituting the parameters obtained from F, for a, b, c, and those from F^{v}, $F^{v\prime}$, $F^{v\prime\prime}$, in succession, for a', b', c', we deduce,

$$\text{Cos. } X = -\frac{2m^2a^2(n^2+2n-2)+3n^2}{4m^2a^2(n^2-n+1)+3n^2}.$$

$$\text{Cos. } Y = -\frac{2m^2a^2(4n-n^2-1)+3n^2}{4m^2a^2(n^2-n+1)+3n^2}.$$

$$\text{Cos. } Z = -\frac{4m^2a^2(n^2-n+1)-3n^2}{4m^2a^2(n^2-n+1)+3n^2}.$$

For the semiangles we may thence obtain,

$$\text{Cos. } \tfrac{1}{2} X = \frac{ma(2-n)}{M};\ \text{cos. } \tfrac{1}{2} Y = \frac{ma(n-1)\sqrt{3}}{M};\ \text{cos. } \tfrac{1}{2} Z = \frac{n\sqrt{3}}{M};$$

in which equations, $M = \sqrt{(4m^2a^2(n^2-n+1)+3n^2)}$;

whence, cos. $\frac{1}{2}X$: cos. $\frac{1}{2}Z$ :: $ma(2-n) : n\sqrt{3}$,
cos. $\frac{1}{2}Y$: cos. $\frac{1}{2}Z$ :: $ma(n-1) : n$,
cos. $\frac{1}{2}X$: cos. $\frac{1}{2}Y$ :: $2-n : (n-1)\sqrt{3}$.

Representing the inclination of two faces over an axial basal angle, (angle at edge X,) by T, and that over a diagonal angle, (angle at edge Y,) by U, the same process as above, with a subsequent deduction of the tangent from the cosine, gives,

$$\text{tan. } \tfrac{1}{2} T = \frac{man\sqrt{3}}{\sqrt{(m^2a^2(2-n)^2+3n^2)}},\quad \text{tan. } \tfrac{1}{2} U = \frac{ma(n+1)}{\sqrt{3}\sqrt{(m^2a^2(n-1)^2+n^2)}}.$$

b. By making $n = \frac{m}{m-1}$, we find for the relations of the semiangles of $mP\frac{m}{m-1}$, cos. $\frac{1}{2}X$: cos. $\frac{1}{2}Z$ :: $a(m-2) : \sqrt{3}$.

Cos. $\frac{1}{2}Y$: cos. $\frac{1}{2}Z$ :: $a : 1$.
Cos. $\frac{1}{2}X$: cos. $\frac{1}{2}Y$ :: $m-2 : \sqrt{3}$.

Also for the values of T and U,

$$\text{tan. } \tfrac{1}{2} T = \frac{ma\sqrt{3}}{\sqrt{(a^2(m-2)^2+3)}},\quad \text{tan. } \tfrac{1}{2} U = \frac{(2m-1)a}{\sqrt{3}\sqrt{(a^2+1)}}.$$

Observing that $\tan.\ \frac{1}{2}\ U' = \frac{a\sqrt{3}}{\sqrt{(a^2+1)}}$, U' being the corresponding angle in the fundamental form, we obtain,

$$2m - 1 = \frac{3\tan.\ \frac{1}{2}U}{\tan.\ \frac{1}{2}U'} = 3\tan.\ \tfrac{1}{2}\,U \times \cot.\ \tfrac{1}{2}\,U'.$$

From which equation, if U and U' are known, m may be found.

c. In the prism ∞Pn,

$$\tan.\ \tfrac{1}{2}X = \frac{n\sqrt{3}}{2-n},\quad \tan.\ \tfrac{1}{2}\ Y = \frac{n+1}{(n-1)\sqrt{3}}.$$

Consequently, $\frac{n}{2-n} = \sqrt{\tfrac{1}{3}} \times \tan.\ \frac{1}{2}X$, and $\frac{n+1}{n-1} = \sqrt{\tfrac{1}{3}} \times \tan.\ \frac{1}{2}\ Y$.

d. In the pyramid mP, in which $n = 1$, we have,

$$\tan.\ \tfrac{1}{2}\ X = \frac{\sqrt{(m^2a^2+1)}\sqrt{3}}{ma},\quad \tan.\ \tfrac{1}{2}\ Z = \tan.\ \tfrac{1}{2}\ U = 2ma\sqrt{\tfrac{1}{3}},$$

$$\tan.\ \tfrac{1}{2}\ T = \frac{ma\sqrt{3}}{\sqrt{(m^2a^2+3)}}.$$

From the angle Z we obtain, $ma = \frac{\sqrt{3}}{2}\tan.\ \frac{1}{2}\ Z$.

Or since $2a\sqrt{\frac{1}{3}} = \tan.\ \frac{1}{2}\ Z'$ in the fundamental form,

$$m = \frac{\tan.\ \frac{1}{2}Z}{\tan.\ \frac{1}{2}Z'} = \frac{\tan.\ \frac{1}{2}U}{\tan.\ \frac{1}{2}U'} = \tan.\ \tfrac{1}{2}\,U \times \cot.\ U'.$$

e. In $mP2$,

$$\tan.\ \tfrac{1}{2}\ Y = \frac{\sqrt{(3m^2a^2+4)}}{ma},\quad \tan.\ \tfrac{1}{2}Z = \tan.\ \tfrac{1}{2}\,T = ma,$$

$$\tan.\ \tfrac{1}{2}\ U = \frac{ma\sqrt{3}}{\sqrt{(m^2a^2+4)}}.$$

From $\tan.\ \frac{1}{2}Z$, $m = \frac{\tan.\ \frac{1}{2}Z}{a}$, but in the form $P2$, in which $m = 1$, $\tan.\ \frac{1}{2}Z'' = a$. Consequently,

$$m = \frac{\tan.\ \frac{1}{2}Z}{\tan.\ \frac{1}{2}Z''} = \tan.\ \tfrac{1}{2}Z \times \cot.\ \tfrac{1}{2}Z''.$$

2. *Hemihedral Forms.*

a. The scalenohedron, $\frac{mPn}{2}$, (fig. 116.)

The formulas for the cosines of the angles are determined in the manner heretofore described.

$\text{Cos.}\ \frac{1}{2}X = \frac{ma\sqrt{3}}{M}$, M being equal to $\sqrt{(4m^2a^2(n^2-n+1)+3n^2)}$.

$$\text{Cos.}\ \tfrac{1}{2}\ Y = \frac{ma(n-1)\sqrt{3}}{M},\quad \cos.\ \tfrac{1}{2}Z = \frac{\sqrt{(m^2a^2(2-n^2)+3n^2)}}{M},$$

$$\sin.\ \tfrac{1}{2}Z = \frac{man\sqrt{3}}{M}.$$

Whence, $\text{Cos.}\ \frac{1}{2}X : \cos.\ \frac{1}{2}\ Y :: 1 : n-1.$
$\text{Cos.}\ \frac{1}{2}X : \sin.\ \frac{1}{2}Z :: 1 : n.$
$\text{Cos.}\ \frac{1}{2}\ Y : \sin.\ \frac{1}{2}Z :: n-1 : n.$

For the value of n, we obtain from these proportions,

$$n=\frac{\cos.\frac{1}{2}Y+\cos.\frac{1}{2}X}{\cos.\frac{1}{2}X};\quad n=\frac{\sin.\frac{1}{2}Z}{\cos.\frac{1}{2}X};\quad n=\frac{\sin.\frac{1}{2}Z}{\sin.\frac{1}{2}Z-\cos.\frac{1}{2}Y}.$$

Designating the inclination of the longest terminal edge on the terminal axis by α, and that of the shorter by β,

$$\text{Cot.}\,\alpha=\frac{ma\,(n+1)}{n\sqrt{3}},\quad \cot.\,\beta=\frac{ma(2n-1)}{n\sqrt{3}}.$$

b. Rhombohedrons $\pm\frac{mP}{2}$, or mR.

$$\text{Cos.}\,X=\frac{2m^2a^2-3}{4m^2a^2+3}=-\cos.\,Z.\quad Y=180^\circ.$$

$$\text{Cot.}\,\alpha=2ma\sqrt{\tfrac{1}{3}}.\quad \text{Cot.}\,\beta=ma\sqrt{\tfrac{1}{3}}.$$

$$\text{Whence, } ma=\frac{\cot.\,\alpha}{\sqrt{\frac{4}{3}}}=\frac{\sqrt{3}\cot.\,\alpha}{2}.$$

$$\text{Also, } ma=\frac{\cot.\,\beta}{\sqrt{\frac{1}{3}}}=\sqrt{3}\cot.\,\beta.$$

$m=\frac{\cot.\,\alpha}{\cot.\,\alpha'}$, α' being the corresponding angle in the fundamental rhombohedron, and $m=\frac{\cot.\,\beta}{\cot.\,\beta'}$.

c. The angles of $\frac{m'Pn'}{2}$ in terms of m and n of the sign mR^n, may be obtained by substituting in the expressions deduced for these angles, $m'n'$ for m, and $\frac{2n'}{n'-1}$ for n, (§ 60.)

The results obtained are,

$$\tan.\,\tfrac{1}{2}X=\frac{\sqrt{(m^2a^2(3n-1)^2+12)}}{ma(n+1)\sqrt{3}},\quad \tan.\,\tfrac{1}{2}Y=\frac{\sqrt{(m^2a^2(3n+1)^2+12)}}{ma(n-1)\sqrt{3}},$$

$$\tan.\,\tfrac{1}{2}Z=\frac{man\sqrt{3}}{\sqrt{(m^2a^2+3)}}.$$

$$\text{Also, } \cos.\,\tfrac{1}{2}X:\cos.\,\tfrac{1}{2}Y::n+1:n-1\quad\therefore\frac{n+1}{n-1}=\frac{\cos.\,\frac{1}{2}X}{\cos.\,\frac{1}{2}Y}.$$

$$\cos.\,\tfrac{1}{2}X:\sin.\,\tfrac{1}{2}Z::n+1:2n\quad\therefore\frac{n+1}{2n}=\frac{\cos.\,\frac{1}{2}X}{\sin.\,\frac{1}{2}Z}.$$

$$\cos.\,\tfrac{1}{2}Y:\sin.\,\tfrac{1}{2}Z::n-1:2n\quad\therefore\frac{n-1}{2n}=\frac{\cos.\,\frac{1}{2}Y}{\sin.\,\frac{1}{2}Z}.$$

d. Forms $r\,\frac{mPn}{2}$, and $l\,\frac{mPn}{2}$.

$$\text{Tan.}\,\tfrac{1}{2}Z'=\tan.\,\tfrac{1}{2}U,\quad \tan.\,\tfrac{1}{2}Z=\tan.\,\tfrac{1}{2}T.$$

$$\text{If } n=\frac{m}{m-1},\quad \tan.\,\tfrac{1}{2}Z'=(2m-1)\times\frac{a}{\sqrt{3}\sqrt{(a_2+1)}},$$

$$\text{or } 2m-1=\text{Tan.}\,\tfrac{1}{2}Z'\times\frac{\sqrt{3}\sqrt{(a^2+1)}}{a}.$$

In quartz, $\frac{\sqrt{3}\sqrt{(a^2+1)}}{a}=2{\cdot}34\ \therefore 2m-1=\tan.\,\tfrac{1}{2}Z'\times 2{\cdot}34.$

e. In the prism ∞R^n,

$$\text{Cos.}\,X=-\frac{3n^2-6n-1}{2(3n^2+1)},\quad \cos.\,Y=\frac{3n^2+6n-1}{2(3n^2+1)},\quad \cos.\,Z=\frac{3n^2-1}{3n^2+1}.$$

62.—V. COMBINATIONS OF TETRAXONAL PLANES.

a. Hexagonal pyramids mP, (fig. 124.)

$m'P2$	1. Truncation of terminal edge of mP,	$m'=m$
	2. Replacement of lateral angle; I-E. par. to terminal edge of mP, (fig. 127,)	$m'=2m$
$\infty P2$	3. Truncation of basal angles.	
∞P	4. Truncation of basal edges.	

b. $mP2$, (similar to fig. 124.)

$m'P$	1. Trunc. of edges of $mP2$,	$m'=\frac{3}{4}m$.
$\infty P2$	2. Trunc. of basal edges.	
∞P	3. Trunc. of basal angles.	

c. ∞Pn.

∞P	1. Trunc. of edge Y of ∞Pn.	
$\infty P2$	2. Trunc. of edge X of ∞Pn.	

63. *a.* mR^n, (fig. 124.)

$m'R^{n'}$	1. Bev. of obtuse Term-E,	$m'(3n'+1)=m(3n+1)$
	2. Bev. of acute Term-E,	$m'(3n'-1)=m(3n-1)$
	3. Bev. of basal edges,	$m'=m$
	4. Terminal angle replaced by 6 pl.; I-E. horizontal,	$n'=n$
	5. Terminal angle replaced by 6 pl.; I-E par. to basal edges of mR^n,	$m'=m$
	6. Basal-A. rep. by 2 pl.; I-E. horizontal,	$n'=n$
$m'R$	7. Trunc. of obt. Term-E.	$m'=\frac{1}{4}m(3n+1)$
	8. Rep. of Term-A. by 3 rbc. pl.	$m'=m$
$-m'R$	9. Trunc. of acute Term-E.	$m'=\frac{1}{4}m(3n-1)$
	10. Rep. Lat. A.; I-E. par. to obt. Term-E.	$m'=\frac{1}{3}m(3n+1)$
$\infty R^{n'}$	11. Rep. of Bas-A.; I-E. horizontal,	$n'=n$
∞R	12. Trunc. of basal angles.	
$\infty P2$	13. Trunc. of basal edges.	

b. mR, (fig. 107.)

$m'R^{n'}$	1. Bev. of Lat-E. of mR, (fig. 115,)	$m'=m$
	2. Bev. of Term-E. of mR, (fig. 117,)	$\frac{1}{4}m'(3n'+1)=m$
$-m'R$	3. Trunc. of Term-E. (fig. 119,)	$m'=\frac{1}{2}m$
	4. Rep. of Lat-A.; I-E. par. to inc. diagonal,	$m'=2m$
$\infty R^{n'}$	5. Rep. of Lat-A. by two pl., (fig. 118.)	
∞R	6. Trunc. of Lat-A, (fig. 111.)	
$\infty P2$	7. Trunc. of Lat-E., (fig. 109.)	
$m'P2$	8. Rep. of Lat-A. by 2 pl.; I-E. par. to inc. diag.	$m'=\frac{4}{3}m$

c. $mP2$.

$m'R^{n'}$	1. Bev. of alternate Term-E. of $mP2$,	$\frac{1}{4}m'(3n'+1)=m$
$m'R$	2. Trunc. of alternate Term-E. of $mP2$,	$m'=\frac{3}{4}m$
	3. Rep. of Lat-A.; I-E. par. to Term-E.	$m'=\frac{3}{2}m$

64.—VI. EQUATIONS FOR THE PARAMETERS OF PLANES FORMING PARALLEL INTERSECTIONS WITH TWO HEMIHEDRAL FORMS.

$$mR^n$$

$+ m'R^{n'}$; $m''n''(m - m') \pm m'n'(m'' - m) - mn(m'' - m') = 0$. In this equation the upper sign is used when the two planes forming the intersections incline towards the same poles of the vertical axis; the lower, when they incline to different poles. When the form $m''R^{n''}$ has the general representative sign $m''P2$, this equation becomes $m''(m - m') + mm'(n + n') = 0$.

$- mR^{n'}$; $m''n''(m + m') \mp m'n'(m'' - m) - mn\,(m'' - m') = 0$. If $m''R^{n''} = m''P2$, $m''(m + m') - mm'(n \pm n') = 0$.

$m'P2$; $m''(n'' - n)m \pm m'(m'' - m) = 0$.

VII. INTERFACIAL ANGLES OF DIFFERENT TETRAXONAL FORMS.

65. The method of deducing the cosines has been sufficiently explained.

$$\text{Cos. } m'Pn' \text{ on } mPn = -\frac{2mm'a^2(2nn' - n - n' + 2) + 3nn'}{MM'}.$$

$M = \surd(4m^2a^2(n^2 - n + 1) + 3n^2$. $M' = \surd(4m'^2a^2(n'^2 - n' + 1) + 3n'^2$.

In the following values the negative sign is omitted:

	$0P$	xPn	$mP2$
$m'Pn'$	$\frac{n'\surd3}{M'}$	$\frac{m'a(2nn' - n - n' + 2)}{M'\surd(n^2 - n + 1)}$	$\frac{n(mm'a^2 + 1)\surd3}{M'\surd m^2a^2 + 1}$
$m'P2$	$\surd(m'^2a^2 + 1)$	$\frac{m'an\surd3}{\surd(m'^2a^2 + 1)\surd(n^2 - n + 1)}$	$\frac{mm'a^2 + 1}{\surd(m'^2a^2 + 1)\surd(m^2a^2 + 1)}$
$\infty Pn'$	0	$\frac{2nn' - n - n' + 2}{2\surd(n'^2 - n' + 1)\surd(n^2 - n + 1)}$	

The cosine of the inclination of

$$\left.\begin{array}{r} mR^n : +m'R^{n'} \\ -mR^n : -m'R^{n'} \end{array}\right\} = -\frac{mm'a^2(3nn' \pm 1) \pm 3}{NN'};$$

$$\left.\begin{array}{r} mR^n : -m'R^{n'} \\ -mR^n : +m'R^{n'} \end{array}\right\} = -\frac{mm'a^2(3nn' \mp 1) \pm 3}{NN'}.$$

$$\left.\begin{array}{r} mR^n : +m'R \\ -mR^n : -m'R \end{array}\right\} = -\frac{mm'a^2(3n \pm 1) \pm 3}{N\surd(4m'^2a^2 + 3)};$$

$$\left.\begin{array}{r} mR^n : -m'R \\ -mR^n : +m'R \end{array}\right\} = -\frac{mm'a^2(3n \mp 1) \mp 3}{N\surd(4m'^2a^2 + 3)}.$$

$$mR^n : \dot{m}'P2 = -\frac{(mnm'a^2 \pm 1)\surd3}{N\surd(m'^2a^2 + 1)}.$$

In these equations,

$$N = \surd(m^2a^2(3n^2 + 1) + 3). \quad N' = \surd(m'^2a^2(3n'^2 + 1) + 3).$$

The cosines of the inclination $\frac{mPn}{2} : \frac{m'Pn'}{2}$, when both forms are inclined to the same pole of the vertical axis,

$$= -\frac{2mm'a^2(2nn' - n - n' + 2) + 3nn'}{MM'};$$

when inclined to different poles,

$$= -\frac{2mm'a^2(nn' + n + n' - 2) - 3nn'}{MM'}.$$

Similarly, cos. of $\frac{mPn}{2} : -\frac{m'Pn'}{2}$, when the two planes are inclined to the same pole,

$$= -\frac{2mm'a^2(nn' + n + n' - 2) + 3nn'}{MM'};$$

when inclined to different poles,

$$= -\frac{2mm'a^2(nn' - n - n' + 2) - 3nn'}{MM'}.$$

VIII. EXAMPLES ILLUSTRATIVE OF THE METHOD OF DETERMINING THE CRYSTALLOGRAPHIC SIGNS OF PLANES IN THE TETRAXONAL SYSTEM.

1. *Apatite*, (figure, p. 186.)

66. This figure represents a hexagonal prism, with truncated lateral edges and replaced basal edges and angles. The plane e may be selected as a face of the fundamental pyramid. Then

$P = 0P$, $M = \infty P$, $e = \infty P2$, (§ 62, *a*, 3.)

a truncates a terminal edge of P, and therefore $= P2$, (§ 62, *a*, 3.)

The edge a′ : e is parallel to a *terminal edge* of P, since it is parallel to the edges of the plane a, which truncates this edge; consequently, a′ $= 2P2$, (§ 62, *a*, 2.)

The edge a : e′ is parallel to a terminal edge of e′; therefore, since a $= P2$, e′ $= \frac{1}{2}P$, (§ 62, *a*, 2.)

a′ ($2P2$) truncates a lateral edge of the pyramid e″ (mP), and therefore, e″ $= 2P$, (§ 62, *a*, 1.)

The edge a″ : e″ is parallel to a terminal edge of e″ ($2P$); consequently, a″ $= 4P2$, (§ 62, *a*, 2.)

Description of the crystal:

$\infty P.\ \ \infty P2.\ \ 0P.\ \ \frac{1}{2}P.\ \ P.\ \ 2P.\ \ P2.\ \ 2P2.\ \ 4P2.$

2. *Calcareous Spar*, (fig. 2, p. 193.)

67. This figure is secondary to a rhombohedron. Its larger faces belong to a scalenohedron. Its primary faces are marked R.

a is a face of a hexagonal prism, and equals ∞R, (§ 63, *a*, 12.)

The interfacial angle *a′* : *a*, diminished by 90°, equals the inclination of *a′* on the base, = the angle β; and since $m = \frac{\cot. \beta}{\cot. \beta'}$,

(§ 61, *b*,) β' being the corresponding angle in the primary, $a' = -2R$.

The edges $R : e'$, $e' : e'$, $e' : R$, are situated one above the other, (the two planes R, being at opposite extremities of the crystal,) and are parallel ; consequently, $e' : e'$, are faces of a scalenohedron, R^n, (§ 63, *b*, 1.) But also the planes a' $(-2R)$ truncate the acute terminal edges of the scalenohedron. It follows, therefore, that $e' = R^3$, (§ 63, *a*, 9.)

The terminal edges of the primary are truncated by $e = -\frac{1}{2}R$, (§ 63, *b*, 3.)

The plane e′ forms a horizontal intersection with e' (R^3) and is, therefore, of the general form mR^3, (§ 63, *a*, 4.) Also, because it bevels the terminal edge of the primary R, $\frac{1}{2}m'(3n' - 1) = m$, (§ 63, *b*, 2.) Since $n' = 3$, we have $4m' = m = 1$ and $m' = \frac{1}{4}$, therefore $e' = \frac{1}{4}R^3$.

The two adjacent planes e′ $(\frac{1}{4}R^3)$ form parallel intersections with two faces of the rhombohedron a'', and therefore bevel its terminal edges ; consequently, since $\frac{1}{2}m'(3n' + 1) = m$, (§ 63, *a*, 10,) $a'' = -\frac{5}{4}R$.

Description of the crystal :

$$R^3. \quad \tfrac{1}{4}R^3. \quad \infty R. \quad -\tfrac{5}{4}R. \quad \tfrac{1}{2}R. \quad -2R. \quad R.$$

3. *Crichtonite*, (figure, p. 384.)

68. This figure is in part hemihedral. Its primary faces are lettered R. $a = 0R$.

The edge R : a being at right angles to the edge $R : o'$, (this is apparent in the crystal though not in the figure, an orthographic projection of it,) the plane o' intersects R parallel to the inclined diagonal of the latter. The edge $R : a'$ is also parallel to the same inclined diagonal, and in addition, the edge between R above and a' below is horizontal. Therefore, since R is a face of a rhombohedron, a' is also the face of a rhombohedron ; and because of the parallelism of the edge $R : a'$ to the inclined diagonal, as above stated, $a' = -2R$, (§ 63, *b*, 4.)

Hence follows also, $o' = \frac{4}{3}P2$, (§ 63, *b*, 8.)

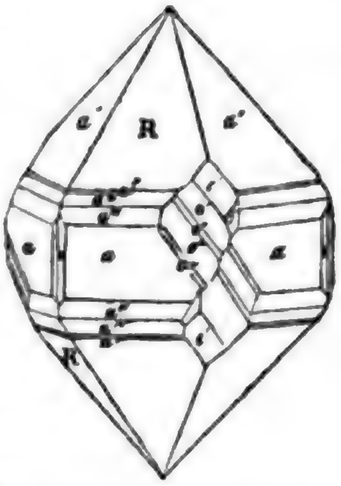
The intersection $a' : a''$ is horizontal, and besides, the edge $R : a''$ is at right angles to a$(0R)$. Therefore, $a'' = -\frac{1}{2}R$.

This might have been determined by the parallelism of the edges $a : a'$, $o : a''$.

4. *Quartz*, (fig. 7, p. 339.)

69. In this figure, R, a'', are the planes of the fundamental pyramid. a''', a^{iv}, a^{v}, are other pyramids, and the obliquely situated planes tetartohedral forms. $a = \infty P$.

The edge $R : e'$ being parallel to a terminal edge of the fundamental pyramid, $e' = 2P2$, (§ 62, *a*, 2.)



Because the intersections of the planes o', o'', o''', o^{iv}, are parallel to e', they have the general sign $mP\frac{m}{m-1}$.

The signs of the planes a''', a^{iv}, a^{v}, may be determined by measuring the inclination $a : a'''$, $a : a^{\text{iv}}$, $a : a^{\text{v}}$, in the manner heretofore described. They are thus found to be

$$a^{\text{v}} = \tfrac{5}{3}P,\ a^{\text{iv}} = 3P,\ a''' = 4P.$$

The inclinations of o', o'', o''', o^{iv}, o^{v}, on the face a, diminished by 90°, equal each the semiangle Z', (§ 61,) and by the formula in the same paragraph, (§ 61, d,)

$$2m - 1 = 2{\cdot}34 \text{ tan. } \tfrac{1}{2} Z', \text{ we obtain,}$$

$$o^{\text{v}} = r\frac{3P\frac{3}{2}}{4},\ o' = l\frac{4P\frac{4}{3}}{4},\ o'' = l\frac{5P\frac{5}{4}}{4},\ o''' = l\frac{6P\frac{6}{5}}{4},\ o^{\text{iv}} = l\frac{8P\frac{8}{7}}{4}.$$

Description of the crystal: $P.\ \infty P.\ 2P2.\ \tfrac{5}{3}P.\ 3P.\ 4P.$

$$r\frac{3P\frac{3}{2}}{4}.\ \ l\frac{4P\frac{4}{3}}{4}.\ \ l\frac{5P\frac{5}{4}}{4}.\ \ l\frac{6P\frac{6}{5}}{4}.\ \ l\frac{8P\frac{8}{7}}{4}.$$

The following are the descriptive expressions of the figures on Pl. II., belonging to Class Tetraxona:

107 and 108.	$R.$
109.	$R.R\infty$, or $mR.mR^{\infty}$.
110.	$mR^{\infty}.mR.$
111.	$R.\infty R.$
112.	$\infty R.R.$
113.	$R.0R.$
114.	$0R.\infty R$, or $P.\infty P.$
115.	$R.R^{n}$, or $mR\ mR^{n}$.
116.	$mR^{n}.$
117.	$R.m'R^{n'}.$
118.	$R.m'R^{n'}.$
119.	$R.-\tfrac{1}{2}R$, or $mR.-\frac{m}{2}R.$
120.	$-\tfrac{1}{2}R.$
121.	$R.-2R$, or $mR.-2mR.$
122.	$-2R.$
123.	$R.-R.$
124.	$R.-R$, or $P.$
125.	$0P.mP.\infty P.\infty P2.$
126.	$mPn.$
127.	$P.2P2$, or $mP.2mP2.$

CLASS TRIMETRICA.

70. Fig. 76, a rhombic octahedron, is the fundamental form in this class. The parametric ratio of its faces is $a : b : c$, these letters representing the semiaxes. Its terminal edges are unequal: one may be called the macrodiagonal, the other the brachydiagonal terminal edge: the former is connected with the *longer* lateral axis or diagonal, the latter with the *shorter* lateral axis or diagonal. Forms making horizontal intersections with P have the general sign mP. Truncation of the basal edges produces a prism ∞P, (the lateral planes of the primary rhombic prism.)

Since the basal angles of the fundamental form are unequal, and also the terminal edges, they are modified independently, and require each a distinguishing mark. The plane truncating the shorter edge is parallel to the longer lateral axis; it is therefore designated $\bar{P}\infty$. The truncation of the other terminal edge produces a plane, parallel to the shorter axis; this may be expressed by $\breve{P}\infty$. Other planes, on the lateral angles, will have the signs $m\bar{P}\infty$ or $m\breve{P}\infty$, according as they are parallel or incline to the longer or shorter lateral axis, when these faces are parallel also to the vertical axis, $m=\infty$, and the planes have the sign $\infty\bar{P}\infty$ or $\infty\breve{P}\infty$. These are the larger and smaller lateral faces of the right rectangular prism. Intermediate planes are as usual designated mPn. According to their relation to the lateral axis, they are distinguished by the marks — or ⌣ over the P, as, $m\bar{P}n$, $m\breve{P}n$.

I. CALCULATIONS OF THE INTERFACIAL ANGLES OF THE TRIMETRIC FORMS.

71. The equations of the faces of the fundamental octahedron are the following:

$$\text{For } F,\ \frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1. \qquad \text{For } F',\ \frac{x}{a}+\frac{y}{b}-\frac{z}{c}=1.$$

$$F'',\ \frac{x}{a}-\frac{y}{b}+\frac{z}{c}=1. \qquad F''',\ -\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1.$$

By introducing the parameters from these equations in the general formula, § 19, we obtain,

$$\text{Cos. } X=\frac{a^2b^2-c^2a^2-b^2c^2}{a^2b^2+c^2a^2+b^2c^2}.$$

$$\text{Cos. } Y=\frac{c^2a^2-a^2b^2-b^2c^2}{a^2b^2+c^2a^2+b^2c^2}.$$

$$\text{Cos. } Z=\frac{b^2c^2-a^2b^2-a^2c^2}{a^2b^2+c^2a^2+b^2c^2}.$$

Hence we have for the cosines of the semiangles,

$$\text{Cos. } \tfrac{1}{2}X=\frac{ab}{M}, \qquad \text{Cos. } \tfrac{1}{2}Y=\frac{ac}{M}, \qquad \text{Cos. } \tfrac{1}{2}Z=\frac{bc}{M},$$

in which $M=\sqrt{a^2b^2+c^2a^2+b^2c^2}$.

Finally, also,

$$\text{Tan. } \tfrac{1}{2}X=\frac{c\sqrt{(a^2+b^2)}}{ab},\ \text{tan. } \tfrac{1}{2}Y=\frac{b\sqrt{(a^2+c^2)}}{ac},\ \text{tan. } \tfrac{1}{2}Z=\frac{a\sqrt{(b^2+c^2)}}{bc}.$$

By writing in these formulas, ma for a, nb for b, nc for c, according to the values of these quantities in any given form, the angle X, Y, Z, for that form, may be determined.

We thus deduce for the prisms,

a. 1. ∞P, tan. $\tfrac{1}{2}X'=\frac{c}{b}$.
2. " tan. $\tfrac{1}{2}Y'=\frac{b}{c}$.
3. $\infty\breve{P}n$, tan. $\tfrac{1}{2}X=\frac{nc}{b}$.
4. $\infty\breve{P}n$, tan. $\tfrac{1}{2}Y=\frac{b}{nc}$.
5. $\infty\bar{P}n$, tan. $\tfrac{1}{2}X=\frac{c}{nb}$.
6. " tan. $\tfrac{1}{2}Y=\frac{nb}{c}$.

Consequently, from equations 1 and 3, $n = \tan.\ \frac{1}{2}\ X + \tan.\ \frac{1}{2}\ X'$, ($\alpha$); 1 and 5, $n = \tan.\ \frac{1}{2}\ X' + \tan.\ \frac{1}{2}\ X$, ($\beta$); 2 and 4, $m = \tan.\ \frac{1}{2}\ Y'$ $\tan.\ \frac{1}{2}\ Y$, (γ); 2 and 6, $n = \tan.\ \frac{1}{2}\ Y + \tan.\ \frac{1}{2}\ Y'$, ($\delta$); in which the marked letters represent the angles of the form ∞P.

b. If $c = \infty$, as in the forms $m\breve{P}\infty$ and $\breve{P}\infty$,

$$\text{in } m\breve{P}\infty,\ \tan.\ \tfrac{1}{2}\ Y = \frac{b}{ma};\ \tan.\ \tfrac{1}{2}\ Z = \frac{ma}{b};$$

$$\text{in } \breve{P}\infty,\ \tan.\ \tfrac{1}{2}\ Y' = \frac{b}{a};\ \tan.\ \tfrac{1}{2}\ Z' = \frac{a}{b}.$$

Consequently, $m = \tan.\ \frac{1}{2}\ Y' + \tan.\ \frac{1}{2}\ Y$, ($\epsilon$); $m = \tan.\ \frac{1}{2}\ Z + \tan.\ \frac{1}{2}\ Z'$, ($\zeta$).

c. If $b = \infty$, as in the forms $m\bar{P}\infty$ and $\bar{P}\infty$,

$$\text{in } m\bar{P}\infty,\ \tan.\ \tfrac{1}{2}\ X = \frac{c}{ma};\ \tan.\ \tfrac{1}{2}\ Z = \frac{ma}{c};$$

$$\text{in } \bar{P}\infty,\ \tan.\ \tfrac{1}{2}\ X' = \frac{c}{a};\ \tan.\ \tfrac{1}{2}\ Z' = \frac{a}{c}.$$

Consequently, $m = \tan.\ \frac{1}{2}\ X' + \tan.\ \frac{1}{2}\ X$, ($\eta$); $m = \tan.\ \frac{1}{2}\ Z + \tan.\ \frac{1}{2}\ Z'$, ($\theta$).

The values of *m* and *n* here deduced, might have been derived from plane trigonometry, employing the right angled triangles formed by the semiaxes.

In the same manner we may obtain the value of *m* in mP, the inclination of mP on ∞P being given. For, subtracting 90° from this inclination, the tangent of the remaining angle varies as the length of the vertical axis, which is the perpendicular, in the triangle containing the given angle. Consequently, representing the constant base of this triangle by p, and the given angle by ρ, $\tan.\ \rho = \frac{ma}{p}$; and if $m = 1$, as in P, $\tan.\ \rho' = \frac{a}{p}$.

We hence have $m = \tan.\ \rho \times \frac{p}{a} = \tan.\ \rho \times \cot.\ \rho'$.

II. DETERMINATION OF THE DIMENSIONS OF OCTAHEDRONS.

72. In the preceding paragraphs the method of determining the angles of octahedrons from their axes has been explained. We may also deduce the values of these axes from the observed angles. These values may be directly obtained from the angles of the several diagonal sections.

Let α represent the inclination of the macrod. terminal edge on the vertical axis.

β, the inclination of the brachyd. terminal edge on the vertical axis.

γ, the inclination of a basal edge on the macrodiagonal.

2α, will then equal the terminal angle of the brachyd. horizontal prism; 2β, the terminal angle of the macrod. horizontal prism; 2γ, the macrod. lateral edge of the vertical prisms of the pyramid.

The relations of $a' : b' : c'$ may therefore be determined from these angles:

$$a' : b' : c' = \begin{cases} 1 : \tan.\alpha : \tan.\beta. \\ \cot.\alpha : 1 : \tan.\gamma. \\ \cot.\beta : \cot.\gamma : 1. \end{cases}$$

For the determination of the angles α, β, γ, the following equations may be employed:

$$\text{Cos.}\,\alpha = \frac{\cos.\frac{1}{2}Y}{\sin.\frac{1}{2}X}. \qquad \text{Cos.}\,\beta = \frac{\cos.\frac{1}{2}X}{\sin.\frac{1}{2}Y}.$$

$$\text{Sin.}\,\alpha = \frac{\cos.\frac{1}{2}Z}{\sin.\frac{1}{2}X}. \qquad \text{Cos.}\,\gamma = \frac{\cos.\frac{1}{2}X}{\sin.\frac{1}{2}Z}.$$

$$\text{Sin.}\,\beta = \frac{\cos.\frac{1}{2}Z}{\sin.\frac{1}{2}Y}. \qquad \text{Sin.}\,\gamma = \frac{\cos.\frac{1}{2}Y}{\sin.\frac{1}{2}Z}.$$

$$\text{Tan.}\,\beta = \tan.\tfrac{1}{2}X\sin.\alpha, \quad \tan.\alpha = \tan.\tfrac{1}{2}Y\sin.\beta.$$

$$\text{Cot.}\,\alpha = \tan.\tfrac{1}{2}Z\sin.\gamma.$$

$$\text{Sin.}\,\alpha = \cot.\tfrac{1}{2}X\tan.\beta, \quad \cos.\alpha = \cot.\tfrac{1}{2}X\tan.\gamma.$$

$$\text{Sin.}\,\beta = \cot.\tfrac{1}{2}Y\tan.\alpha, \quad \cos.\beta = \cot.\tfrac{1}{2}Y\tan.\gamma.$$

$$\text{Sin.}\,\gamma = \cot.\tfrac{1}{2}Z\cot.\alpha, \quad \cos.\gamma = \cot.\tfrac{1}{2}Y\cot.\beta.$$

By comparing the angles α, β, γ, with the corresponding angles of the fundamental form, by means of the relations of a, b, c, to these angles, the relative values of m and n for that form may be determined. For the form mPn, ma should be substituted for a, nb for b, and rc for c.

III. COMBINATIONS OF THE TRIMETRIC FORMS.

73. In the following remarks, forms are said to be of the same kind, when connected with the same axis, and consequently having the same mark, ⌣ or —, placed above their signs.

1. $m'\bar{P}n'$, bev. macrod. terminal edge of $m\bar{P}n$, when $\Big\}\ \frac{m'}{n'} = \frac{m}{n}.$
2. $m'\breve{P}n'$, bev. brachyd. terminal edge of $m\breve{P}n$, when
3. $m'Pn'$, bev. brachyd. terminal edge of $m\bar{P}n$, when $\Big\}\ m' = m.$
4. $m'\breve{P}n'$, bev. macrod. terminal edge of $m\breve{P}n$, when
5. $m'\overset{=}{\breve{P}}n'$, bev. basal edges of $m\overset{=}{\breve{P}}'n$, when $n' = m$.

$m\bar{P}n$ replaces the macrod. angle of $m'\bar{P}n'$ by 4 planes; I-E. par. to brachyd. edge, when $m' = m$.

$m\breve{P}n$ replaces the macrod. angle of $m'\breve{P}n'$ by 4 planes; I-E. par. to brachyd. edge, when $\frac{m'}{n'} = \frac{m}{n}$.

$m\breve{P}n$ replaces the brachyd. angle of $m'\bar{P}n'$ by 4 planes; I-E. par. to macrod. edge, when $m' = m$.

$m\bar{P}n$ replaces the brachyd. angle of $m'\bar{P}'n$ by 4 planes; I-E. par. to macrod. edge, when $\frac{m'}{n'} = \frac{m}{n}$.

$m'\overset{=}{\breve{P}}n'$ bevels terminal edge of $m\overset{=}{\breve{P}}$, when, $m' = \frac{m}{n}$.

$m'\breve{\bar{P}}n'$ replaces by 4 pl., lat-ang. of $m\bar{\bar{P}}n$; I-E. par. to terminal edges, when $\frac{m'}{n'}=m$.

$m'\breve{P}n'$ bev. macrod. edge; $m'\bar{P}n'$, bev. brachyd. edge; when $m'=m$.

Rep. of lat. angle; I-E. par. to term-edge of mP, $\frac{m'}{n'}=m$.

$m'\tilde{P}\infty$ trunc. brachyd., $m'\breve{P}\infty$ trunc. macrod. term-edge, $m'=m$.

IV. EQUATIONS FOR THE DETERMINATION OF m AND n FROM THE PARALLEL INTERSECTIONS OF THREE PLANES.

74. For a plane truncating the edge between

$m\breve{\bar{P}}n$ and $m'\bar{P}n'$; $m''n''(m'n-mn')+m''(m-m')nn'+n''(n'-n)mm'=0$.

$m\breve{\bar{P}}n$ and $m'\breve{\bar{\bar{P}}}n'$; $m''n''(m'-mn')n+r''m''(m-m'n)n'+n''r''(n'n-1)m'm=0$.

mP and $m'\breve{\bar{\bar{P}}}n'$; $m''n''(m'-mn')+m''(m-m')n'+n''(n'-1)mm'=0$.
mP and $\infty Pn'$; $m''(n''-n')+n''(n'-1)m=0$.

mP and $m'\breve{\bar{\bar{P}}}\infty$; $m''(m-m')+n''(m'-m'')m=0$.
mP and $\infty P\infty$; $mn''-m''=0$.

∞P and $m'\breve{\bar{\bar{P}}}n'$; $m''(n''-1)n'-n''(n'-1)m'=0$.

∞P and $m'\breve{\bar{\bar{P}}}\infty$; $m''(n''-1)-m'n''=0$.

75. The following are the most important of the general laws for the combinations of different forms:

1. Forms with horizontal intersections have $n=n'$.

2. Each horizontal prism, which truncates the macrod. E. of $m\breve{P}n$, or the brachyd. E. of $m\bar{P}n$, has the general sign $m\breve{P}\infty$ or $m\bar{P}\infty$; but when it truncates the brachyd. E. of $m\breve{P}n$ or macrod. E. of $m\bar{P}n$, its sign equals $\frac{m}{n}\bar{P}\infty$ or $\frac{m}{n}\breve{P}\infty$. The same applies to the form mP, as this is a similar figure in which $n=1$.

3. Each horizontal prism, which replaces the angles of combination between mP and $m'P$, by rbc. planes inclined on the longer or shorter terminal edge, is of the general description,

$$\frac{2mm'}{m+m'}\breve{P} \text{ or } \frac{2mm'}{m+m'}\bar{P}\infty.$$

4. Each horizontal prism, which replaces in the same manner the angle of combination between mP and ∞P, is $2m'\breve{P}\infty$ or $2m'\bar{P}\infty$.

5. Each horizontal prism, which replaces the angle of combination between $\infty\breve{\bar{\bar{P}}}n$ and $m\breve{\bar{\bar{P}}}\infty$ by rbc. planes, is $mn\breve{\bar{\bar{P}}}\infty$.

6. The horizontal prism, which replaces the same between mP' and $\infty\breve{\bar{\bar{P}}}n$ by rbc. planes, have the signs $m(n'+1)\breve{\bar{\bar{P}}}\infty$ or $m\frac{(n'+1)}{n'}\bar{P}\infty$; the one replaces the upper, the other the lower I-E.

7. Each pyramid, which replaces the edge between ∞P and $m\breve{\bar{P}}\infty$, is of the general form $m'\breve{\bar{P}}\frac{m'}{m'-m}$.

8. Each pyramid, which truncates the I-E. between mP and $\infty\breve{\bar{P}}\infty$, has the general sign $mn\breve{\bar{P}}n$.

9. Each pyramid, which bevels the longer or shorter terminal edges of mP, is of the general sign $m\bar{P}n$ or $m\breve{P}n$, in which m(of mP) $= m$(of mPn.)

10. Each pyramid, which replaces the edge between $m\bar{\breve{P}}n$ and $\infty\bar{\breve{P}}\infty$, has $\frac{m'}{n'} = \frac{m}{n}$.

V. CALCULATION OF THE INTERFACIAL ANGLES BETWEEN DIFFERENT FORMS.

76. This is effected by means of the general equation, § 19.
If the forms are $m\bar{P}n$ and $m'\bar{P}n'$, we substitute in that formula,

ma for a, nb for b,
$m'a$ for a', $n'b$ for b', c for c'.

If $m\breve{P}n$ and $m'\breve{P}n'$,

ma for a, nc for c,
$m'a$ for a', b for b', $n'c$ for c'.

If the forms are unlike, as $m'\bar{P}n'$ and $m\breve{P}n$,

ma for a, nc for c,
$m'a$ for a', $n'b$ for b', c for c'.

VI. EXAMPLES ILLUSTRATIVE OF THE METHOD OF DETERMINING THE SIGNS OF TRIMETRIC FORMS.

Arragonite, (figure, p. 195.)

77. This figure represents a rhombic prism with truncated acute lateral edges and replaced basal edges and angles. e is a face of the fundamental pyramid; *M* therefore $= \infty P$.

a, a', a'', are horizontal prisms of the general form $m\breve{P}\infty$.

a truncates the longer terminal edge of e, (P,) and hence $= \breve{P}\infty$, (§ 75, 2.) $\breve{e} = \infty\breve{P}\infty$.

The planes o'' bevels the macrodiagonal terminal edge of P, and hence $= \breve{P}n$, (§ 73, 4.)

Since the I-E between o'' (Pn) and o' is horizontal, $o' = m\breve{P}n$, (§ 75, 1.) But because o' forms parallel intersections with $\breve{e}$ ($\infty\breve{P}\infty$) and e (P), its sign is nPn, (§ 75, 8.) Also, from § 75, 7, $o' = n\breve{P}\frac{n}{n-1}$. Consequently, $o' = 2\breve{P}2$, and $o'' = \breve{P}2$.

The plane a'' truncates the macrod. terminal edge of the pyramid o' $(2\breve{P}2)$, and therefore since $m' = m$, $a'' = 2\breve{P}\infty$, (§ 73, 4.)

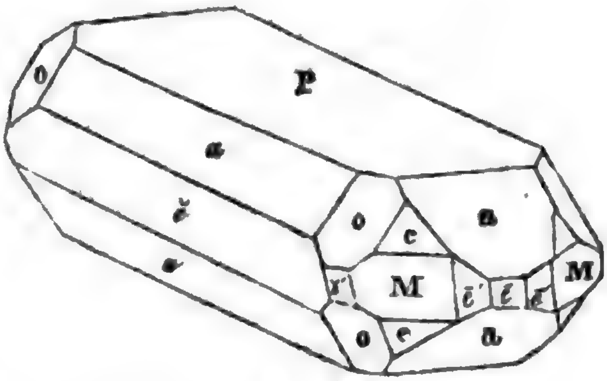
The angle $a' : a' = 140° 23' = Y$. By means of the equation $m = \tan.\frac{1}{2}Y' + \tan.\frac{1}{2}Y$, we may therefore determine the sign of a':

$$m = \frac{\tan.\,54° 13'}{\tan.\,70° 11'} = \frac{1}{2}, \text{ and } a' = \tfrac{1}{2}\breve{P}\infty.$$

Description of the crystal:

$$\infty P. \quad \infty\breve{P}\infty. \quad \breve{P}\infty. \quad P. \quad 2\breve{P}2. \quad \breve{P}2. \quad 2\breve{P}\infty. \quad \tfrac{1}{2}\breve{P}\infty.$$

Heavy Spar.



78. Considering e as a face of the fundamental form,

$P = 0P$; $\bar{e} = \infty\bar{P}\infty$;
$\breve{e} = \infty\breve{P}\infty$; $M = \infty P$;
$a = \breve{P}\infty$.

The angle $\breve{e}' : \breve{e} = 148° 27'$, from which, by subtracting 90°, we obtain X of the prism $\breve{e}' = 58° 27'$. The same angle of $M(\infty P) = 39° 10$; hence $\breve{e}' = \infty P2$, (§ 71, a.)

The intersection of o with $\breve{e}'$ is horizontal; consequently, $n' = n$ and $o = mP2$; and since o is a beveling plane of a terminal edge of the fundamental form, $m = 1$, consequently, $o = \breve{P}2$.

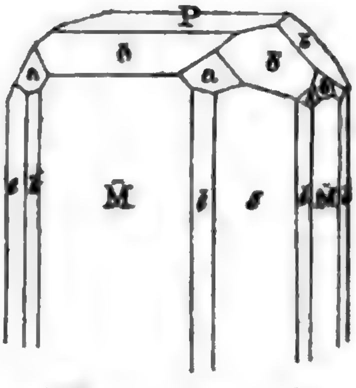
a $(m\bar{P}\infty)$ truncates the brachyd. terminal edge of $\breve{P}2$, and therefore, a $= \frac{1}{2}\bar{P}\infty$, (§ 75, 2.)

A measurement of the angle $\bar{e}' : \bar{e}$, and a comparison of the tangent of that angle with that of $M : \bar{e}$, gives $\bar{e}' = \infty\bar{P}\frac{3}{2}$.

Description of the crystal:

$$0P. \quad \tfrac{1}{2}\bar{P}\infty. \quad \breve{P}\infty. \quad \infty\bar{P}\infty. \quad \infty\breve{P}\infty. \quad \infty P. \quad P. \quad \breve{P}2. \quad \infty\breve{P}2.$$

Columbite.



79. In this figure we may select a, as a face of the fundamental form. The values of its axes are, $a = 1{\cdot}0584 = \sqrt{(1{\cdot}12)}$; $b = 1{\cdot}206 = \sqrt{(1{\cdot}454)}$; $c = 1$. We have $P = 0P$; $\bar{M} = \infty\bar{P}\infty$; $\breve{M} = \infty\breve{P}\infty$; and since the edge a : e is horizontal, (as observed in the crystal, though not in the projection of it in the figure,) $e = \infty P$.

The angle $\breve{M} : \breve{e} = 156° 6'$, and therefore, $\frac{1}{2}X$ in the prism, $\breve{e}(\infty\breve{P}n) = 68° 6'$. Half the same angle in the prism $e(\infty P) = 39° 40'$: hence (§ 71, a) $n = 3$ and $\breve{e} = \infty\breve{P}3$.

Since $\breve{o}'$, $\breve{o}'$, bevel the longer terminal edge of a (P), they have the general sign $\breve{P}n$, (§ 75, 9,) and because also $\breve{o}'$ forms parallel intersections with $\breve{e}\,(\infty\,\breve{P}3)$ and $P\,(0P)$ $\breve{o}' = \breve{P}3$, (§ 75, 1.)

$\bar{e}$ truncates the brachyd. terminal edge of the pyramid $\breve{o}'\,(\breve{P}3)$, and consequently, $\bar{e} = \frac{1}{3}\bar{P}\infty$, (§ 75, 2.)

The planes $\breve{o}''\,(m\breve{P}n)$ replace the edge $\breve{o}'' : \bar{M}$, and therefore, (§ 75, 10,) since $\breve{o}' = \breve{P}3$, $\frac{m}{n} = \frac{1}{3}$. But by a measurement of the interfacial angle $\breve{M} : \breve{e}$ we find it to equal 150° 20′; and hence since (§ 71, b) tan. $\frac{1}{2}Z$ in the prism $\breve{e}\,(m\breve{P}\,\infty) = m\frac{a}{b}$, we deduce, that $\breve{e} = 2\breve{P}\,\infty$. Now $\breve{e}$ truncates the macrod. terminal edge of the pyramid $\breve{o}'$, and consequently, (§ 75, 2,) $\breve{o}'' = 2\breve{P}n$; and since $\frac{m}{n} = \frac{1}{3}$, $n = 6$ and $\breve{o}'' = 2\breve{P}6$.

The inclination of $\bar{e}$ on $\bar{M}$ equals 157° 29′, and hence $\frac{1}{2}$ Y in the prism $\bar{e} = 67°\ 29'$. Therefore, (§ 71, a, δ,) $\bar{e} = \infty\,\bar{P}2$.

The expression thus deduced for the crystal is as follows:

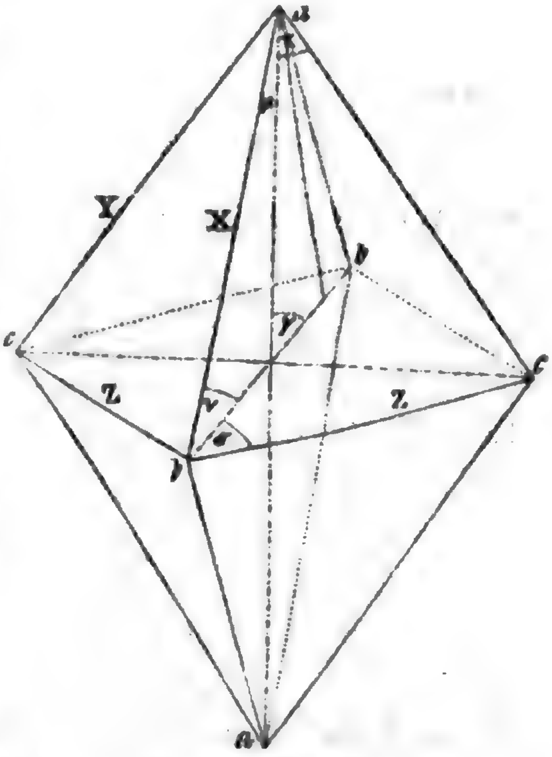
$0P.\ \frac{1}{3}\bar{P}\,\infty.\ P.\ \breve{P}3.\ 2\breve{P}6.\ 2\breve{P}\,\infty.\ \infty\bar{P}\,\infty.\ \infty\bar{P}2.\ \infty P.\ \infty\breve{P}3.\ \infty\breve{P}\,\infty.$

By substituting the values of the axes in the different forms for a, b, c, in the equations § 71, the values of the angles of those forms may be obtained. In this manner we find for the fundamental pyramid $X = 102°\ 58'$, $Y = 117°\ 51'$, $Z = 107°\ 56'$. In the pyramid $\breve{P}3\,(\breve{o}')$ by writing a, b, $3c$, for a, b, c, the same angles for this form may be found; and by substituting $2a$, b, $6c$, for a, b, c, the corresponding angles for the form $2\breve{P}6\,(\breve{o}'')$ may be obtained.

The following are the descriptive expressions of the figures on Pl. II., belonging to Class Trimetrica:

69. $0P.\infty\bar{P}\infty.\infty\breve{P}\infty.$
70 and 71. $0P.\infty\bar{P}\infty.\infty P.\infty\breve{P}\infty.$
72. $0P.\infty P.$
74. $0P.mP.\infty\bar{P}\infty.\infty\breve{P}\infty.$
75. $0P.mP.\infty P.$
76. $P.$
77. $0P.m\bar{P}\infty.\infty\bar{P}\infty.\infty\breve{P}\infty.$
78. $0P.m\breve{P}\infty.\infty\breve{P}\infty.\infty\bar{P}\infty.$
79. $\infty\bar{P}\infty.m\breve{P}\infty.$
80. $0P.m\bar{P}\infty.\infty\bar{P}\infty.\infty\breve{P}\infty.m\breve{P}\infty.$
81. $m\bar{P}\infty.m\breve{P}\infty.$
82. $0P.m\bar{P}\infty.m\breve{P}\infty,\infty P.$
83. $mP.m\bar{P}\infty.$
84. $0P.\infty\bar{P}n.\infty P.$
85. $0P.m\bar{P}n.\infty P.$
86. $m\bar{P}n.0P.\infty P.$

CLASS MONOCLINATA.



80. The annexed figure represents the fundamental octahedron of this class. The lines *a a*, *b b*, *c c*, or more concisely, *a*, *b*, *c*, are its three axes. The inclination of *a* to *b* is an oblique angle; that of *a* to *c*, and that of *b* to *c*, are right angles, from which relation of these angles, as has been heretofore explained, the name of this system of crystallization, *Monoclinate*, is derived. The axis *a* is the vertical axis; the axis *b*, with which *a* forms an oblique angle, is denominated the *clinodiagonal;* and the axis *c*, whose inclination to *a* is a right angle, is the *orthodiagonal.* The same terms are employed in designating the front and lateral terminal edges; the former, which unite the clinodiagonal and vertical axis, being termed the clinodiagonal edges, and the latter, uniting the orthodiagonal and vertical axis, the orthodiagonal edges.

I. CRYSTALLOGRAPHIC SIGNS OF MONOCLINATE FORMS.

81. The fundamental form in this class is composed of two sets of planes, one of which includes the superior frontal and their opposites, and the other the inferior frontal and their opposites behind. These dissimilar parts of the fundamental octahedron, may be distinguished by the use of the signs + and —, designating the upper $+P$, and the lower $-P$, or the reverse. The various forms mP may also be either plus or minus. A replacement of the terminal angle of the fundamental form, by a plane parallel to its base, is designated, as in the preceding classes, $0P$; and a truncation of the basal edges has the sign ∞P. $\infty P.0P$ is therefore the descriptive expression for the oblique rhombic prism.

A bevelment of the front terminal edges of a form $\pm mP$ produces the form $\pm mPn$; and a truncation of the same, the form $\pm mP\infty$.

When the plane $\pm mP\infty$ is parallel to the vertical axis, $m = \infty$, and its sign becomes $\infty P \infty$.

The bevelments and truncation of the orthodiagonal edge and angle may be distinguished by accenting the P. The several forms, with their characteristic mark, will thus be, $\pm mP'n$, $mP' \infty$, and $\infty P' \infty$. The descriptive expression for a right rhomboidal prism, is therefore $0P$. $\infty P \infty$. $\infty P' \infty$.

II. DETERMINATION OF THE INTERFACIAL ANGLES OF THE MONOCLINATE CRYSTALLINE FORMS.

82. We may designate the inclination of a plane P on the clinodiagonal section, by X; on the orthodiagonal section, by Y; on the basal section, by Z; and the corresponding inclinations of $-P$, by the accented letters X', Y$'$, Z'. The angles X, Y, X', Y$'$, are each half the interfacial angle of the octahedron at the edges X, Y, X', Y$'$.

Let also the inclination of a on b be represented by γ.
" " " edge X on a " μ.
" " " " b " ν.
" " " edge X' on a " μ'.
" " " " b " ν'.
" " " edge Y on a " π.
" " " edge Z on b " σ.

By substituting in the value of cos. M, (§ 25,) γ for ϱ, and making successively c', b', and a', $= 0$, since this is the value of one of the parameters in each of the planes of section, we obtain,

$$\text{Cos. } X = \frac{ab \sin.\gamma}{M}; \qquad \text{Cos. } X' = \frac{ab \sin.\gamma}{M'};$$

$$\text{Cos. } Y = \frac{c(a - b \cos.\gamma)}{M}; \qquad \text{Cos. } Y' = \frac{c(a + b \cos.\gamma)}{M'};$$

$$\text{Cos. } Z = \frac{c(b - a \cos.\gamma)}{M}; \qquad \text{Cos. } Z' = \frac{c(b + a \cos.\gamma)}{M'};$$

in which $M = \sqrt{[a^2b^2 \sin.^2\gamma + c^2(a^2 + b^2 - 2ab \cos.\gamma)]}$, and $M' = \sqrt{[a^2b^2 \sin.^2\gamma + c^2(a^2 + b^2 + 2ab \cos.\gamma)]}$.

Each face $\pm mP$, with the clinodiagonal and orthodiagonal sections, and also with the clinodiagonal and basal sections, forms a rectangular trihedral pyramid, from which, by the principles of trihedrometry, the following values of the tangents of these angles are deduced:

$$\text{Tan.} \left\{ \begin{matrix} X \\ X' \end{matrix} \right. = \frac{c\sqrt{(a^2 + b^2 \mp 2ab \cos.\gamma)}}{ab \sin.\gamma}.$$

$$\text{Tan.} \left\{ \begin{matrix} Y \\ Y' \end{matrix} \right. = \frac{b \sin.\gamma \sqrt{(a^2 + c^2)}}{c(a \mp b \cos.\gamma)}.$$

$$\text{Tan.} \left\{ \begin{matrix} Z \\ Z' \end{matrix} \right. = \frac{a \sin.\gamma \sqrt{(b^2 + c^2)}}{c(b \mp a \cos.\gamma)}.$$

In terms of the angles μ, μ', π, σ, the tangents of the same angles become as follows:

$$\text{Tan. } X = \frac{\tan.\sigma}{\sin.(\gamma+\mu)} = \frac{\tan.\pi}{\sin.\mu}; \qquad \tan. X' = \frac{\tan.\sigma}{\sin,(\gamma-\mu')} = \frac{\tan.\pi}{\sin.\mu'};$$

$$\tan. Y = \frac{\tan.\mu}{\sin.\pi}; \qquad \tan. Y' = \frac{\tan.\mu'}{\sin.\pi};$$

$$\tan. Z = \frac{\tan.(\gamma+\mu)}{\sin.\sigma}; \qquad \tan. Z' = \frac{\tan.(\gamma-\mu')}{\sin.\sigma}.$$

It may sometimes be convenient to observe, that $\gamma+\mu = 180^\circ - \nu$, and $\gamma - \mu' = \nu'$; and consequently, $\sin.(\gamma+\mu) = \sin.\nu$, $\sin.(\gamma-\mu') = \sin.\nu'$.

The values of the angles μ, μ', ν, ν', π, σ, may be obtained by either of the following formulas:

$$\text{Tan.}\left\{\begin{matrix}\mu\\ \mu'\end{matrix}\right. = \frac{b\sin.\gamma}{a \mp b\cos.\gamma}, \qquad \tan.\left\{\begin{matrix}\nu\\ \nu'\end{matrix}\right. = \frac{a\sin.\gamma}{b \mp a\cos.\gamma},$$

$$\tan.\pi = \frac{c}{a}, \qquad \tan.\sigma = \frac{c}{b}.$$

$$\cos.\mu = \frac{\cos.Y}{\sin.X}, \qquad \cos.\mu' = \frac{\cos.Y'}{\sin.X'},$$

$$\cos.\nu = \frac{\cos.Z}{\sin.X}, \qquad \cos.\nu' = \frac{\cos.Z'}{\sin.X'},$$

$$\cos.\pi = \frac{\cos.X}{\sin.Y} = \frac{\cos.X'}{\sin.Y'}, \qquad \cos.\sigma = \frac{\cos.X}{\sin.Z} = \frac{\cos.X'}{\sin.Z'}.$$

In the prism ∞P,

$$\text{Tan. } X = \frac{c}{b\sin.\gamma} = \tan. X' = \cot. Y.$$

In the horizontal prisms $P\infty$ and $-P\infty$,

$$\text{Tan.}\left\{\begin{matrix}Y\\ Y'\end{matrix}\right. = \frac{b\sin.\gamma}{a \mp b\cos.\gamma}, \qquad \tan.\left\{\begin{matrix}Z\\ Z'\end{matrix}\right. = \frac{a\sin.\gamma}{b \mp a\cos.\gamma}.$$

In $P'\infty$,

$$\text{Tan. } X = \tan. X' = \frac{c}{a\sin.\gamma}, \qquad \tan. Z = \tan. Z' = \frac{a\sin.\gamma}{c} = \cot. X,$$

$$\tan.\left\{\begin{matrix}Y\\ Y'\end{matrix}\right. = \mp\frac{\tan.\gamma\sqrt{(a^2+c^2)}}{c}.$$

By writing ma for a, these formulas also apply to the form $mP'\infty$.

III. DETERMINATION OF THE LENGTHS OF THE AXES.

83. Several of the preceding formulas may be employed in the determination of the lengths of the axes, according to the data that may be given. The following proportions are also important:

$$a:b:c=1:\frac{\sin.\mu}{\sin.(\gamma+\mu)}:\tan.\pi.$$

$$a:b:c=1:\frac{\sin.\mu'}{\sin.(\gamma-\mu')}:\tan.\pi.$$

$$a:b:c=\frac{\sin.(\gamma+\mu)}{\sin.\mu}:1:\tan.\sigma.$$

$$a:b:c=\frac{\sin.(\gamma-\mu')}{\sin.\mu'}:1:\tan.\sigma.$$

Tan. γ when unknown may be found by the equations,

$$\tan.\gamma=\frac{2\sin.\mu\sin.\mu'}{\sin.(\mu-\mu')},\qquad \tan.\gamma=\frac{2\sin.\nu\sin.\nu'}{\sin.(\nu-\nu')}.$$

IV. RULES FOR THE DETERMINATION OF THE SIGNS OF MONOCLINATE FORMS.

84.—1. Two forms whose faces, inclined to the same pole of the vertical axis, form intersections parallel to the basal section, have $n'=n$.

2. Two forms whose faces inclined to the same pole, form intersections parallel to the orthodiagonal edge; if of the same name and situated on the axis b, are so related, that $\frac{m'}{n'}=\frac{m}{n}$; if on the axis c, $m'=m$. If of different names $\frac{m'}{n'}=m$. The accented letters refer to the form on the orthodiagonal edge.

3. Two forms whose planes, inclined to the same pole, form intersections parallel to the clinodiagonal edge, and are of the same name, if on the axis b, $m'=m$;

if on the axis c, $\frac{m'}{n'}=\frac{m}{n}$.

If unlike, $m'=\frac{m}{n}$.

4. The planes truncating or beveling the clinodiagonal edges of the hemipyramid $\pm mPn$, belong to the hemiprism $\pm mP\infty$, or hemipyramid $\pm mPn'$ in which $n'>n$.

5. The planes truncating or beveling the clinodiagonal edges of the hemipyramid $\pm mP'n$, belong to the hemiprism $\pm\frac{m}{n}P\infty$, or the hemipyramid $\pm\frac{m}{n}Pn'$.

6. Rhombic planes replacing the clinodiagonal angles of intersection of $\pm mP$ and ∞P, belong to the horizontal prism $\pm 2mP\infty$.

7. The edge between $+mP$ or $-mP$ and ∞P inclined to different poles, is truncated by the prism $2mP'\infty$.

8. The edges between the hemipyramid $\pm mP$ and the pairs of

faces $\infty P \infty$ or $\infty P' \infty$, are truncated by the hemipyramid $\pm mnPn$, or $\pm mnP'n$.

Hence it follows, that planes whose intersections with P are parallel to the clinodiagonal or orthodiagonal edges, have the general sign $m'P'm'$, or $m'Pm'$.

9. The edge between $\pm mP\infty$ or $mP'\infty$, and ∞P, is replaced by the hemipyramid $\pm m'P\frac{m'}{m'-m}$, or $m'P'\frac{m'}{m'-m}$.

10. Each pyramid $m''P$, which truncates the edge of intersection of the hemiprisms $\pm mP\infty$, and the prism $m'P'\infty$, is of the form $\frac{mm'}{m+m'}P$. If $m''=1$, $m'=\frac{m}{m-1}$; if $m'=1$, $m''=\frac{m}{m+1}$, or if $m=1$, $m''=\frac{m'}{m'+1}$; if $m'=m$, $m''=\frac{m}{2}$. Each form $m''Pn''$ replacing the same edge has $m''=\frac{n''m'm}{m+n''m'}$.

VI. EXAMPLES ILLUSTRATIVE OF THE ABOVE RULES.

Glauber's Salt, (figure, p. 173.)

85. Considering á as the frontal superior face of the fundamental pyramid, ă $= P$; $T = 0P$; $M = \infty P \infty$; $P = \infty P' \infty$; $e = \infty P$.

ĕ truncates the edge ă : ă, and therefore $= P\infty$, (§ 84, 4.)

The edge ă : e is parallel to the orthodiagonal edge of P. Consequently, e $= P'\infty$.

Since the intersection of e and ā is also parallel to the orthodiagonal edge ā $= -P$.

The plane ă′ forms parallel edges with e ($P'\infty$) and ĕ ($P\infty$), and consequently, ă′ $= \frac{1}{2}P$, (§ 84, 10.)

ĕ′ therefore $= \frac{1}{2}P\infty$, (§ 84, 4.)

e′ truncates an edge between the planes ă (P) and e (∞P) inclined towards different poles. Consequently, e′ $= 2P'\infty$, (§ 84, 7.)

ē ($-mP\infty$) forms parallel intersections with a right hand plane ā ($-P$) and left e ($P'\infty$). Consequently, making, in the general equation,

$$m = 1,\ n = 1,\ r = 1,$$
$$m' = 1,\ n' = \infty,\ r' = -1,$$
$$m'' = m,\ n'' = 1,\ r'' = \infty,$$

we obtain ē $= -\frac{1}{2}P\infty$.

Description of the crystal: ∞P. $\infty P\infty$. P. $P\infty$. $-P$. $P'\infty$. $\frac{1}{2}P$. $-\frac{1}{2}P\infty$. $\frac{1}{2}P\infty$. $0P$. $2P'\infty$. $\infty P'\infty$.

For the calculation of the dimensions of a, b, c, we have the following data:

$$e : e = 86^\circ\ 31',\quad M : \breve{e} = 104^\circ\ 41',\quad M : \bar{e} = 132^\circ\ 4'.$$

Hence, in the prism $e\,(\infty P)$ the angle $X = 43^\circ\ 15\frac{1}{2}'$; in the hemiprism $\breve{e}\,(\frac{1}{3}P\infty)$, $Y = 75^\circ\ 19' = \mu$; in the hemiprism $\bar{e}\,(-\frac{1}{2}P\infty)$ $Y = 47^\circ\ 56' = \mu'$.

Since $\breve{e}$ and $\bar{e}$ are coördinate hemiprisms, the angle γ may be obtained by the equation, $\tan.\gamma = \frac{2\sin.\mu\sin.\mu'}{\sin.(\mu-\mu')}$, (§ 83.) Consequently, $\gamma = 72^\circ\ 15'$.

Making the clinodiagonal (b) equal to unity, it follows that $c = \tan.X\sin.\gamma$, (§ 82;) which angles being known, we find

$$c = 0{\cdot}8962.$$

From § 82, we determine for the prism $\frac{1}{2}P\infty$,

$$\nu = 180^\circ - (\mu + \gamma) = 32^\circ\ 26'.$$

But $a : b :: \frac{\sin.(\gamma+\mu)}{\sin.\mu} : 1$, (§ 83.)

$$\text{Therefore } a = \frac{\sin.\nu}{\sin.\mu} = 0{\cdot}5455,$$

which is a of the form $\frac{1}{2}P\infty$, and consequently, equal $\frac{1}{2}a$ of the fundamental form. Consequently, $a = 1{\cdot}109$.

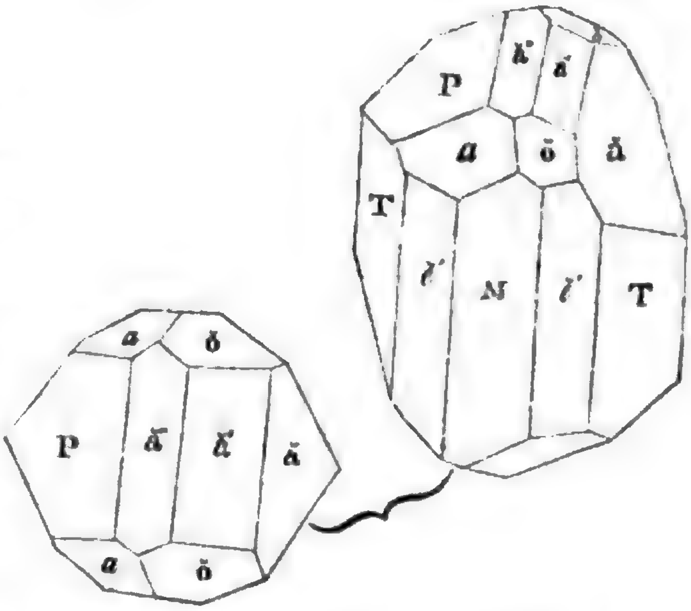
The dimensions of the crystal are, therefore,

$$\gamma = 72^\circ\ 15',$$
$$a : b : c = 1{\cdot}109 : 1 : 0{\cdot}8962.$$

Feldspar.

86. Assuming $\breve{o}$ as a face of the positive hemipyramid (P), $P = 0P$, and $T = \infty P$. Also, $M = \infty P'\infty$; and because $\breve{a}'$ forms parallel edges with $\breve{o}$, $\breve{o}\,(P)\,\breve{a}' = P\infty$.

The plane a, which truncates the orthodiagonal edges of the fundamental pyramid, forms parallel edges with $\breve{o}\,(P)$ and $T\,(\infty P)$. Consequently, $a = 2P'\infty$, (§ 84, 7.)



$\breve{a}$ forms parallel edges with T, and the posterior $\breve{o}\,(P)$, and also with the anterior $\breve{o}$ and posterior T. The face, therefore, if other planes were not present, would have a rhombic form. Hence $\breve{a} = 2P\infty$, (§ 84, 6.)

The prism $\breve{e}'\,(\infty P'n)$, truncates an edge between an upper

$\breve{o}\,(P)$ and an under $a\,(2\,P'\infty\,)$. Substituting, therefore, in the general expressions for planes with parallel intersections,

$m = n = r = 1$; $m' = -2,\ n' = \infty\,,\ r' = 1$; $m'' = \infty\,,\ n'' = n'',\ r'' = 1$;

we find $n = 3$, and therefore, $\breve{e}' = \infty\,P'3$.

The positive hemiprism $\breve{a}''\,(m''P\infty\,)$ intersects with parallel edges the posterior $\breve{o}$ and anterior a. Substituting, therefore,

$m = n = r = 1$; $m' = 2,\ n' = \infty\,,\ r' = -1$; $m'' = m'',\ n'' = 1,\ r'' = \infty$;

we find $m'' = \frac{2}{3}$, and therefore, $\breve{a}'' = \frac{2}{3}P\,\infty$.

Description of the crystal :

$\infty\,P.\quad \infty P'\infty\,.\quad \infty P'3.\quad 0P.\quad 2P\infty\,.\quad P\,\infty.\quad \frac{2}{3}P\infty\,.\quad P.\quad 2P\,\infty.$

87. *Hornblende*, (fig. 4, p. 309.)

Making $\breve{e} = P,\ P = 0P,\ M = \infty\,P$.

As the face $a\ (mP'\infty\,)$ truncates an edge between the two faces $\breve{e}\,(P)$ and $M(\,\infty\,P)$ inclined to different poles, $a = 2P'\infty$, (§ 83, 7 ;) and $\bar{e} = -\,P$, since a replaces also the edge between $\bar{e}$ behind and M in front.

The hemipyramids $\breve{o}$ and $\bar{o}$ are of the general form $mP'm$, (§ 84, 12.) But also since they truncate the edge between $a\,(2P\,\infty)$ and M, they are of the form $mP\frac{m}{m-2}$, (§ 84, 9.) Consequently, $\frac{m}{m-2} = 3$, and $\breve{o} = 3P'3,\ \bar{o} = -\,3P'3$. We have, therefore, for the description of the crystal :

$\infty P.\quad \infty P'\infty\,.\quad 0P.\quad P.\quad -\,P.\quad 2P'\infty\,.\quad 3P'3.\quad -\,3P'3.$

For the determination of the dimensions of the axes of this crystal we have given,

Angle X in $\infty P = 62°\ 15'$; angle X in $P = 74°\ 15' = X'$,

and the interfacial angle $0P : \infty P = 103°\ 1' = \Pi$.

$$\text{Cos.}\ \sigma = \frac{\cos.\ X}{\sin.\ \Pi},\quad \cos.\ \gamma = \frac{\cos.\ \Pi}{\sin.\ X}.$$

Consequently, $\sigma = 61°\ 27'$, and $\gamma = C = 75°\ 15'$.

Again, $\sin.\ \nu = \tan.\ \sigma\ \cot.\ X'$, and therefore, $\nu = 31°\ 13'$, and $\mu = 73°\ 32'$.

Considering the clinodiagonal b equal to unity,

The orthodiagonal $c = \tan.\ \sigma = 1{\cdot}838$.

The vertical axis $a = \frac{\sin.\ \nu}{\sin.\ \mu} = 0{\cdot}5405$.

We have therefore, $a : b : c = 0{\cdot}5405 : 1 : 1{\cdot}838$.

The following are the descriptive expressions of the figures on Plate II., belonging to the Class Monoclinata :

88. $0P.\infty P\infty.\infty P'\infty$.

90. $0P.\infty P\infty.\infty P.\infty P'\infty$.

91. $0P.\infty P$.

93. $0P.mP\infty.\infty P\infty.\infty P'\infty$.

94. $0P.-mP\infty.\infty P\infty.\infty P'\infty$.

95. $0P.mP'\infty.\infty P\infty.\infty P'\infty$.

96. $0P.mP\infty.\infty.P$.

97. $0P.-mP\infty.\infty P$.

98. $0P.mP'\infty.\infty P$.

99. $mP\infty.-mP\infty.mP'\infty$.

100. $0P.\infty P.\infty Pn.\infty P'\infty$.

101. $0P.mP.\infty P$.

102. $0P.mP.\infty P\infty.\infty P'\infty$.

CLASS TRICLINATA.

I. CRYSTALLOGRAPHIC SIGNS OF TRICLINATE FORMS.

88. The fundamental octahedron contains three unequal and obliquely inclined axes. The longer of the horizontal axes is termed the *macrodiagonal*, (from μακρὸς, *long*,) and the shorter, the *brcahydiagonal*, (from ϐραχυς, *short*.) The vertical sections passing through these diagonals are called respectively, the macrodiagonal, and the brachydiagonal section. The opposite planes, merely, of the fundamental form, are similar and equal; and consequently, it is designated by the expression ${}_{\prime}^{\prime}P_{\prime}^{\prime}$, and its front planes severally, P', $'P$, ${}_{\prime}P$, $P_{\prime}$ in which expressions the position of the accent marks the situation of the plane. The posterior planes have the same symbols as the front planes to which they are parallel.

Planes on the edges may be expressed by affixing to the letter P the two accents which belong to the planes including the edge, as $m\,'P'\infty$, $m\,{}_{\prime}P'n$; and different forms mP, may be distinguished by the accent of the plane P on which they are inclined; as mP', if inclined on P', $m\,{}_{\prime}P$, if on ${}_{\prime}P$. Planes on the different terminal edges, or basal angles, are still farther distinguished by the mark — or ⌣ over the letter P, according as they are parallel or inclined to the macrodiagonal or brachydiagonal; as $m\,'\bar{P}'\infty$, $m\,{}_{\prime}\breve{P}\infty$.

The replacement of the terminal angle by a plane parallel to the basal plane may be designated, as heretofore, by the expression $0P$; and the similar replacements of the basal angles may be expressed by $\infty\bar{P}\infty$ and $\infty\breve{P}\infty$.

II. DETERMINATION OF THE INTERFACIAL ANGLES OF TRICLINATE FORMS.

89. *a.* Let the mutual inclination of the sectional planes of the fundamental form at their intersections in the axes a, b, c, be rep-

resented respectively by A, B, C; and the inclination of the axes by α, β, γ: that is, the inclination of a on b, by γ, a on c, by β, b on c, by α. Let also the inclinations of a face of the fundamental octahedron, on the macrodiagonal, brachydiagonal, and basal sections, be represented by X, Y, Z, respectively, and finally the inclinations of the edge
X on a by μ,
X on b by ν,
Y on a by π,
Y on c by ρ,
Z on b by σ,
Z on c by τ,

$$\mu+\nu+\gamma=\pi+\rho+\beta=\sigma+\tau+\alpha=180^\circ.$$

b. The following are the values of the cosines of α, β, γ, in terms of the cosines and sines of the angles A, B, C:

$$\text{Cos.}\,\alpha=\frac{\cos.A+\cos.B\cos.C}{\sin.B\sin.C}.$$

$$\text{Cos.}\,\beta=\frac{\cos.B+\cos.A\cos.C}{\sin.A\sin.C}.$$

$$\text{Cos.}\,\gamma=\frac{\cos.C+\cos.A\cos.B}{\sin.A\sin.B}.$$

c. The same angles may be determined by means of the values of μ, ν, or σ, &c. of any form, and the corresponding μ', ν', or σ', of the coördinate form. The following equations may be employed for this purpose:

$$\tan.\,\alpha=\frac{2\sin.\sigma\sin.\sigma'}{\sin.(\sigma-\sigma')}=\frac{2\sin.\tau\sin.\tau'}{\sin.(\tau-\tau')}.$$

$$\tan.\,\beta=\frac{2\sin.\pi\sin.\pi'}{\sin.(\pi-\pi')}=\frac{2\sin.\rho\sin.\rho'}{\sin.(\rho-\rho')}.$$

$$\tan.\,\gamma=\frac{2\sin.\mu\sin.\mu'}{\sin.(\mu-\mu')}=\frac{2\sin.\nu\sin.\nu'}{\sin.(\nu-\nu')}.$$

90. By a continuation of the same process that afforded the equation of a plane in the monoclinate system, (§ 24,) we may readily obtain the orthometric equation for a plane in the triclinate system. In the former case, there was but one oblique inclination between the three axes; in the latter, all these inclinations are oblique. But, although the equations thus obtained are important in some investigations into the relations of different solids, the crystallographer will find other methods of calculation much more simple and sufficient for all his purposes. These equations are therefore omitted.

91. The three sections, the macrodiagonal, brachydiagonal, and basal, divide the fundamental octahedron into three-sided pyramids. If the plane in the basal section is considered the base, and the vertical solid angle of the octahedron, the vertex of one of these pyramids, its lateral interfacial angles are identical with the angles X, Y, and A; and since the terminal edges are X, Y, and the axes a, the plane angles at the summit are $X:Y$, $X:a$, and $Y:a$, of which,

the two last angles equal respectively μ and π. If we make the vertex A a centre, and describe with a certain radius an arc on each of the faces, a spherical triangle is formed, whose angles equal the inclinations of the faces of the pyramid, viz. X, Y, A, and whose sides are measured by the plane angles at the vertex, two of which are μ and π. In this spherical triangle, if the angles A, μ, and π are given, (that is, two sides, μ and π and the included angle A,) the angles X and Y are readily determined by Napier's theorem.

1. $$\text{Tan.}\,\tfrac{1}{2}(X+Y)=\cot.\,\tfrac{1}{2}A\,\frac{\cos.\,\frac{1}{2}(\pi-\mu)}{\cos.\,\frac{1}{2}(\pi+\mu)}.$$

$$\text{Tan.}\,\tfrac{1}{2}(X-Y)=\cot.\,\tfrac{1}{2}A\,\frac{\sin.\,\frac{1}{2}(\pi-\mu)}{\sin.\,\frac{1}{2}(\pi+\mu)}.$$

This gives the half sum and half difference of the angles X and Y, from which the angles themselves are easily obtained. In a similar way are deduced the following analogous formulas:

2. For X and Z, from B, ν and σ:

$$\text{Tan.}\,\tfrac{1}{2}(X+Z)=\cot.\,\tfrac{1}{2}B\,\frac{\cos.\,\frac{1}{2}(\sigma-\nu)}{\cos.\,\frac{1}{2}(\sigma+\nu)}.$$

$$\text{Tan.}\,\tfrac{1}{2}(X-Z)=\cot.\,\tfrac{1}{2}B\,\frac{\sin.\,\frac{1}{2}(\sigma-\nu)}{\sin.\,\frac{1}{2}(\sigma+\nu)}.$$

3. For Y and Z, from C, ϱ and τ,

$$\text{Tan.}\,\tfrac{1}{2}(Y+Z)=\cot.\,\tfrac{1}{2}C\,\frac{\cos.\,\frac{1}{2}(\tau-\rho)}{\cos.\,\frac{1}{2}(\tau+\rho)}.$$

$$\text{Tan.}\,\tfrac{1}{2}(Y-Z)=\cot.\,\tfrac{1}{2}C\,\frac{\sin.\,\frac{1}{2}(\tau-\rho)}{\sin.\,\frac{1}{2}(\tau+\rho)}.$$

When the angles X and Y in any particular form are desired, it will be necessary to obtain the values of μ and π for that form, and with these values and the angle A, the desired angle may be obtained by the above equations. In a similar manner, Y and Z, and X and Z, may be known from τ and ϱ and σ and ν. If X and Y are determined, and ν and ϱ are known, Z may be obtained by the equation,

$$\cos.\,Z=\frac{\cos.\,B}{\sin.\,\psi}\sin.\,(X-\psi),$$

$$\text{or}\quad \cos.\,Z=\frac{\cos.\,C}{\sin.\,\psi}\sin.\,(Y-\psi),$$

in which ψ is an angle to be determined by the equation,

$$\cot.\,\psi=\cos.\,\nu\,\tan.\,B,$$

$$\text{or}\quad \cot.\,\psi=\cos.\,\varrho\,\tan.\,C.$$

By varying these formulas, X may be obtained when Y and Z is known, and Y, when X or Z is known.

92. The following trigonometrical formulas for the values of μ, ν, π, ϱ, σ, τ, may be employed to determine these angles. It must be observed, that when either of the angles α, β, γ, are obtuse, the cosine becomes minus:

$$\text{Tan.}\,\mu=\frac{b\sin.\gamma}{a-b\cos.\gamma},\quad \tan.\,\nu=\frac{a\sin.\gamma}{b-a\cos.\gamma},$$

$$\text{Tan.}\ \pi = \frac{c \sin.\beta}{a - c\cos.\beta},\ \tan.\ \varrho = \frac{a\sin.\beta}{c - a\cos.\beta},$$

$$\text{Tan.}\ \sigma = \frac{c\sin.\alpha}{b - c\cos.\alpha},\ \tan.\ \tau = \frac{b\sin.\alpha}{c - b\cos.\alpha}.$$

These angles, as functions of the angles **X**, **Y**, **Z**, may be found by the following formulas:

$$\text{Cos.}\ \mu = \frac{\cos.Y + \cos.X\cos.A}{\sin.X\sin.A},\quad \cos.\ \nu = \frac{\cos.Z + \cos.X\cos.B}{\sin.X\sin.B.},$$

$$\text{Cos.}\ \pi = \frac{\cos.X + \cos.Y\cos.A}{\sin.Y\sin.A},\quad \cos.\ \varrho = \frac{\cos.Z + \cos.Y\cos.C}{\sin.Y\sin.C.},$$

$$\text{Cos.}\ \sigma = \frac{\cos.X + \cos.Z\cos.B}{\sin.Z\sin.B},\quad \cos.\ \tau = \frac{\cos.Y + \cos.Z\cos.C}{\sin.Z\sin.C}.$$

Formulas, analogous to the following, may also be employed.

$$\text{Cos.}^2\ \tfrac{1}{2}\ \mu = \frac{\cos.(S - X)\cos.(S - A)}{\sin.X\sin.A},$$

in which $S = \frac{1}{2}(Y + X + A)$. Their only advantage consists in their admitting more conveniently the use of logarithms.

The following relations subsist between the interfacial angles, and the angles of the sections:

$$\text{Sin.}\ X : \sin.\ Y :: \sin.\ \pi : \sin.\ \mu,$$
$$\text{Sin.}\ Y : \sin.\ Z :: \sin.\ \tau : \sin.\ \rho,$$
$$\text{Sin.}\ Z : \sin.\ X :: \sin.\ \nu : \sin.\ \sigma,$$

and consequently,

$$\text{Sin.}\ \mu \sin.\ \rho \sin.\ \sigma = \sin.\ \nu \sin.\ \pi \sin.\ \tau.$$

If μ is known, π may therefore be found by the equation,

$$\text{Sin.}\ \pi = \frac{\sin.\mu\sin.X}{\sin.Y}.$$

Similar equations may be obtained for the angles ν, ρ, &c.

93. *a. Interfacial angles of the vertical hemiprism.* The angles σ and τ are first to be found from the values of b, c, and α, in the hemiprism, and then according to the Napierian theorem,

From σ, γ, and B, we determine X and Z; or
from τ, β, and C, we determine Y and Z.

When X or Y has been found, the equation $A + X + Y = 180°$, will give the unknown angle.

b. Inclined macrodiagonal hemiprism. From a, c, β, the angles π and ρ may be obtained, and then by the Napierian theorem,

X and Y may be found, from π, γ, and A;
Z and Y, from ρ, α, and C.

Finally, we have $B + X + Z = 180°$.

c. Inclined brachydiagonal hemiprism. From b, a, γ, the angles μ and ν may be found, and then by the Napierian theorem,

X and Y from μ, β, and A;
X and Z from ν, α, and B;
$C + Y + Z = 180.$

III. DETERMINATION OF THE DIMENSIONS OF TRICLINATE FORMS.

94. *a.* Several of the preceding formulas may assist in determining the lengths of the axes. The following proportions and equations are also important:

$$\text{Sin. } \mu : \text{sin. } \nu :: b : a ; \quad \text{sin. } \varpi : \text{sin. } \rho :: c : a ; \quad \text{sin. } \sigma : \text{sin. } \tau :: c : b.$$

If X and Y, in a vertical prism, are known, we may employ the relation,

$$b : c :: \text{sin. } Y \text{ sin. } \beta : \text{sin. } X \text{ sin. } \gamma.$$

If X and Z, in an inclined macrodiagonal hemiprism, are known, we have the relation,

$$a : c :: \text{sin. } Z \text{ sin. } \alpha : \text{sin. } X \text{ sin. } \gamma.$$

If Y and Z, in an inclined brachydiagonal hemiprism, are known, we may find the relative values by the proportion,

$$a : b :: \text{sin. } Z \text{ sin. } \alpha : \text{sin. } Y \text{ sin. } \beta.$$

b. When, in these several hemiprismatic forms, an edge is measured which is not parallel to the axis of the hemiprisms, the plane angle of the prismatic faces must first be found, and then the Napierian theorem may be applied as follows:

1. If Z is given in the vertical prism,

$$\text{Sin. } \upsilon = \frac{\text{sin. } B \text{ sin. } \gamma}{\text{sin. } Z}, \quad \text{or sin. } \xi = \frac{\text{sin. } C \text{ sin.} \beta}{\text{sin. } Z};$$

and then,

$$\text{Tan.} \tfrac{1}{2} \sigma = \text{tan.} \tfrac{1}{2} (\upsilon - \gamma) \frac{\text{sin. } \frac{1}{2}(B+Z)}{\text{sin. } \frac{1}{2}(B-Z)},$$

$$\text{or,} \quad \text{tan. } \tfrac{1}{2} \tau = \text{tan. } \tfrac{1}{2} (\xi - \beta) \frac{\text{sin.} \frac{1}{2} (C+Z)}{\text{sin.} \frac{1}{2} (C-Z)}.$$

2. If Y is given in the inclined macrodiagonal prism,

$$\text{Sin. } \zeta = \frac{\text{sin. } A \text{ sin. } \gamma}{\text{sin. } Y}, \quad \text{or sin. } \xi = \frac{\text{sin.} C \text{ sin. } \alpha}{\text{sin. } Y}.$$

$$\text{Tan. } \tfrac{1}{2} \varpi = \text{tan. } \tfrac{1}{2} (\zeta - \gamma) \frac{\text{sin.} \frac{1}{2}(A+Y)}{\text{sin.} \frac{1}{2}(A-Y)},$$

$$\text{or,} \quad \text{tan.} \tfrac{1}{2} \rho = \text{tan. } \tfrac{1}{2} (\xi - \alpha) \frac{\text{sin.} \frac{1}{2} (C+Y)}{\text{sin.} \frac{1}{2} (C-Y)}.$$

3. If X is given in the inclined brachydiagonal hemiprism,

$$\text{Sin.} \zeta = \frac{\text{sin. } A \text{ sin. } \beta}{\text{sin. } X}, \quad \text{or sin. } \upsilon = \frac{\text{sin. } B \text{ sin. } \alpha}{\text{sin.} X}.$$

$$\text{Tan. } \tfrac{1}{2} \mu = \text{tan. } \tfrac{1}{2} (\zeta - \beta) \frac{\text{sin.} \frac{1}{2} (A+X)}{\text{sin.} \frac{1}{2} (A-X)},$$

$$\text{or,} \quad \text{tan.} \tfrac{1}{2} \nu = \text{tan. } \tfrac{1}{2} (\upsilon - \alpha) \frac{\text{sin.} \frac{1}{2}(B+X)}{\text{sin.} \frac{1}{2}(B-X)}.$$

IV. DETERMINATION OF THE SIGNS OF PLANES.

95. The following general rules are obvious deductions from the principles heretofore explained:

If two planes form, by their intersection, an edge parallel to the

$$\begin{cases} 1.\ \text{basal section, } b : c :: b' : c', \\ 2.\ \text{mocrodiagonal section, } a : b :: a' : b', \\ 3.\ \text{brachydiagonal section, } a : c :: a' : c'. \end{cases}$$

The formulas and rules deduced for the trimetric and monoclinate forms, will be found of essential importance, also, in this system of crystallization. From § 84, 6, it results, that when a face replacing the angle between mP', $m'P$, $\infty P'_{,}$, and $\infty{}'_{,}P$, has a rhomboidal form, its sign is of the form $2m\,\infty P'_{,}$. Other laws are derived with equal facility from the remaining paragraphs in the same section.

V. EXAMPLE OF THE APPLICATION OF THE PRECEDING PRINCIPLES.

Anorthite, (figure, p. 298.)

96. $P = 0P$; $T = \infty P'_{,}$; $M = \infty\,{}'_{,}P$; $\bar{e} = {}'P$.

Since $\bar{a}'$ replaces the edge $\hat{e}\,({}'P) : T(\infty P'_{,})$, forming parallel intersections with these planes, $\bar{a}' = 2'P'\infty$.

For a similar reason, ${}'a = 2'\breve{P}_{,}\infty$.

Since the edge ${}'\breve{e} : \breve{e}'$, which is replaced by $\breve{a}$, is parallel to the shorter terminal edge of the fundamental form, ${}'\bar{e} = {}_{,}P$, $\breve{e}' = P_{,}$ and $\breve{a} = {}_{,}\bar{P}_{,}\infty$. In the same manner as above we also obtain,

$$\breve{a}' = 2_{,}\bar{P}_{,}\infty,\ {}''\breve{e} = 2_{,}P,\ a' = 2_{,}\breve{P}'\infty.$$

The descriptive expression for the crystal is therefore,

$0P$. $\infty P'_{,}$. $\infty{}'_{,}P$. ${}'P$. $2'\bar{P}'\infty$. $2'\breve{P}_{,}\infty$. ${}_{,}P$. $P_{,}$. ${}_{,}\bar{P}_{,}\infty$. $2_{,}\bar{P}_{,}\infty$. $2_{,}P$. $2\breve{P}'\infty$.

For the determination of the dimensions of the crystal, we have the following angles given by Rose:

$P : \breve{e}$ (a plane, $\infty\breve{P}\infty$, replacing the acute lateral edges parallel to the brachydiagonal) $= 85° 48'$.

$T : \breve{e} = 117° 28°$, $T : M = 120° 30'$,
$P : a' = 133° 13'$, $P : T = 110° 57'$.

The supplement of the angle $T : \breve{e}$, 62° 32′, is the angle Y for $\infty P'_{,}$. By subtracting this angle from $T : M$, we find the angle Y for $\infty\,{}'_{,}P = 57° 58' = Y'$. The supplement of $P : T$, 69° 3′, is the angle Z in $\infty P'_{,}$.

The angle $P(0P) : M(\infty\breve{P}\infty) = C = 85° 48'$. The supplement of the angle $P : a' = 46° 47'$, is the angle Z in $2_{,}\breve{P}'\infty = Z'$.

From the angles X, Y, C, we find the angle β at the centre equal to 63° 45′. And since

$$\sin.\tau = \frac{\sin.Y \sin.\beta}{\sin.Z},$$

the angle τ in $\infty P'_{,} = 58° 26'$. From β, Y', and $180° - C$, the corresponding angle τ' for $\infty{}'_{,}P$ is found equal to 56° 35′.

Since τ' and τ are the corresponding angles in coördinate hemiprisms, we find by the formula, § 89, c, $\alpha = 88° \; 42'$. And because, $\sigma + \tau + \alpha = 180°$, (§ 89, a,) $\sigma = 180° - (\alpha + \tau) = 32° \; 52'$.

Consequently, as $b : c :: \sin. \tau : \sin. \sigma$, if we let c, the half of the brachydiagonal, equal unity, $b = 1{\cdot}57$.

In the brachydiagonal hemiprism, we have given the angle

$Z' = 46° \; 47'$; and since $Y' + Z' + C = 180°$, (§ 93,)

$Y' = 180° - (Z' + C) = 47° \; 25'$.

Consequently, from the proportion $\sin. Z' \sin. \alpha : \sin. Z \sin. \beta :: 2\alpha : b$, we obtain, $a = 0{\cdot}866$.

If desired, the angles A, B, and γ, may now be determined by the Napierian theorem, from the known values of C, α, β. In this manner we obtain,

$$A = 87° \; 0', \qquad B = 116° \; 23', \qquad \gamma = 86° \; 48\tfrac{1}{2}'.$$

The following are the deduced dimensions of the crystal:

$$a : b : c :: 0{\cdot}866 : 1{\cdot}57 : 1,$$
$$A = 87°, \quad B = 116° \; 23', \quad C = 85° \; 48',$$
$$\alpha = 88° \; 42', \quad \beta = 116° \; 15', \quad \gamma = 86° \; 48\tfrac{1}{2}'.$$

The foregoing treatise on Mathematical Crystallography, has been necessarily concise: too much so, perhaps, for the satisfaction of the thorough student of science. Still, it will probably be found sufficient with but few, if any exceptions, for all the calculations the mineralogist or crystallographer may find it necessary to compute. For a more complete account of this subject, I can refer to no superior work than that by Dr. C. F. Naumann, which is the basis of the system adopted. It contains an elaborate development of every part of the subject, philosophically and perspicuously arranged. Its author has deduced not merely the formulas for the *interfacial and plane angles*, but also those for the superficial and solid contents of the several crystalline forms; and, moreover, has given the corresponding simplified formulas for the different relative values of m and n. The nature of compound crystals has also been fully considered, and their respective formulas for calculation determined; and by the application of the same general but simple principles of analytical geometry, he has mathematically investigated the laws for the orthographic projection of crystals, and derived formulas for the accurate construction of models.

I should be unjust to the science, and to one of its most illustrious cultivators, should I close this subject without allusion to the original investigations of M. Mohs, in this branch of mathematics. So nearly contemporaneous were the crystallographic labors of Mohs and Weiss, that there is yet some doubt as to priority. Their names will ever be united—as is happily expressed by Naumann in the dedication of his work—as the "*Coryphæi of German Crystallographers.*"

APPENDIX B.

CHEMICAL CLASSIFICATION.

THE classification of Mohs, which has been adopted in the preceding part of this treatise, more clearly exhibits the affinities of the mineral species, than any arrangement founded on a less general view of the relations of the species, and is best adapted to convey a comprehensive, systematic, and intelligible idea of the Science of Mineralogy. It is, however, frequently desirable, especially with the chemist and metallurgist, to view minerals simply in their chemical relations. The following chemical classification of the mineral species is therefore subjoined.

Chemical arrangements may be of two kinds; 1, the general divisions may be formed by associating compounds, containing the same *electro-negative* element; 2, these divisions may depend on the *electro-positive* element.

In a classification of the first kind, in which the various mineral species are arranged according to the electro-negative part of their constitution, the binary compounds would be distributed into two classes, according as they form acid (electro-negative) or non-acid (electro-positive) compounds, with oxygen, chlorine, iodine, sulphur, &c.; and the species, produced by the union of individuals of these two classes, would constitute a third class of *salts*. The subdivisions of these classes would depend on the particular electro-negative element in the composition of each of the species. Consequently, we should have families of oxyds, chlorids, sulphurets, &c.; of oxacids, chloracids, sulphacids, &c.; of oxysalts, chlorosalts, sulphosalts, &c.

The second method of classification associates all species containing the same *electro-positive* element, or compound. Thus all the compounds of a particular base, as potash, copper, iron, &c., are collected into separate families.

Since the development of the electrical relations of the elements and their compounds by Berzelius, the superiority of the former of these methods of classification has been very generally admitted. The electro-negative constituent is, in general, the characterizing ingredient. The sulphurets of different metals are far more closely allied than the oxyds, sulphurets, and salts, of the same metal. Yet this is not invariably true, and the apparent exceptions to it as a general rule, strongly convince us of the futility of attempts to form a *natural* arrangement of the mineral species upon chemical principles merely. The physical characters of a compound rather depend on the mutual natures of the elements, than on the peculiarities of either one. Nitrate of lime and nitrate of magnesia have close resemblances, which appear to depend on the *nitric acid* (electro-negative part) in their constitution. With sulphuric acid, however, the salts of lime and magnesia are wholly unlike, and in the case of the salt of lime, we should say, that the *lime* (electro-positive part) was here the characterizing ingredient, and the species appears to be more naturally associated with carbonate of lime than with other sulphates. When chemistry has so far advanced, that the relative electro-negativity, (if I may so call it,) or electro-positivity, of the several elements, is fully known, and when we are accurately acquainted with their several idiosyncrasies, we shall probably be able to construct a natural arrangement of minerals on chemical principles.

The principles of isomorphism, for the development of which we are indebted principally to Mitscherlich, have made new difficulties apparent in the second of the above methods of classification. When two electro-positive constituents are substituted for one another in a compound, without changing its physical characters, it is evident that this compound belongs equally to two distinct families in this classification. Such instances are not infrequent. In individuals of the species pyroxene, the magnesia may be partially or wholly replaced by protoxyd of iron, without any essential change in the external characters. Garnet and hornblende have a similarly varying constitution. This consideration led Berzelius originally to reject the electro-positive for the electro-negative arrangement. Later discoveries have shown that in a similar manner two *electro-negative* constituents may mutually replace one another, thus introducing objections also to the latter arrangement; though not as weighty, since the instances are less numerous.

Although the electro-negative arrangement is decidedly preferable for an exhibition of the chemical relations of the species, the electro-positive has its advantages in another point of view: it subserves more conveniently the purposes of the metallurgist. His pursuits lead him to an investigation of minerals with respect to their metallic constituents, for which object he would naturally associate the mineral species according to the metal in their composition. The wants of the latter class of readers have been considered of paramount importance; and, therefore, in order to afford a convenient table of reference to those interested in the metallic constitution of the mineral species, at the same time that a chemical view of the species is presented, the classification founded on the electro-positive constituent is here adopted.

To facilitate a reference to the description of the species, the number of the page is added, on which each is described.

TABULAR VIEW

OF A

CHEMICAL CLASSIFICATION OF MINERALS.

Class I. Non-metallic elements, and their compounds.
Class II. Metallic elements, and their compounds.

CLASS I. NON-METALLIC ELEMENTS, AND THEIR COMPOUNDS.

I. NON-ACID INDIVIDUALS.

Genus 1. Hydrogen.

Hydrogen, 165.
Phosphuretted Hydrogen, 165.
Carburetted Hydrogen, 165.

Genus 2. Nitrogen.

Nitrogen, 166.
Atmospheric Air, 166.

Genus 3. Sulphur.

Native Sulphur, 436.

Genus 4. Carbon.

Diamond, 331.
Anthracite, 443.
Graphite, 443.
Bituminous Coal, 442.
Bitumen, 441.
Mineral Caoutchouc, 440.
Retinite, 440.
Amber, 438.
Scheererite, 439.

II. ACID INDIVIDUALS.

Genus 1. Hydrogen.

Muriatic Acid, 167.
Sulphuretted Hydrogen, 166.

Genus 2. Sulphur.

Sulphurous Acid, 167.
Sulphuric Acid, 167.

Genus 3. Carbon.

Carbonic Acid, 166.

Genus 4. Boron.

Boracic Acid, 168.

Genus 5. Silicium.

Quartz, 338.
Opal, 344.
Obsidian, 345.
Sphærulite, 346.

CLASS II. METALLIC ELEMENTS, AND THEIR COMPOUNDS.

Genus 1. Ammonia.*

Sal Ammoniac, *Muriate of Ammonia*, 175.
Mascagnine, *Sulphate of Ammonia*, 174.

Genus 2. Potassium.

Nitrate of Potash, 176.

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* The metallic nature of one of the constituents of ammonia has long been suspected, though it is not yet proved.

GENUS 3. SODIUM.

Glauber's Salt, *Sulphate of Soda*, 173.
Thenardite, *Anhydrous Sulphate of Soda*, 173.
Aphthitalite, 175.
Nitrate of Soda, 176.
Natron, *Carbonate of Soda*, 171.
Trona, *Sesquicarbonate of Soda*, 172.
Gay-Lussite, *Carbonate of Soda and Lime*, 171.
Common Salt, *Chlorid of Sodium*, 172.
Borax, *Biborate of Soda*, 169.
Glauberite, 181.
Polyhalite, 181.

GENUS 4. BARIUM.

Heavy Spar, *Sulphate of Baryta*, 203.
Dreelite, 203.
Baryto-Calcite, 202.
Witherite, *Carbonate of Baryta*, 203.

GENUS 5. STRONTIUM.

Celestine, *Sulphate of Strontia*, 201.
Strontianite, *Carbonate of Strontia*, 200.

GENUS 6. CALCIUM.

Gypsum, *Sulphate of Lime*, 190.
Anhydrite, *Anhydrous Sulphate of L.*, 191.
Haidingerite, 190.
Apatite, *Phosphate of Lime*, 186.
Nitrate of Lime, 176.
Calcareous Spar, } *Carbonate of Lime*,
Arragonite, } 193, 195.
Dolomite, *Carbonate of Magnesia and L.*, 196.
Ankerite, *Carbonate of Iron and L.*, 197.
Fluor Spar, *Fluorid of Calcium*, 185.
Gismondine, *Sesquisilicate of Lime*, 301.
Tabular Spar, *Bisilicate of Lime*, 304.
Datholite, *Borosilicate of L.*, 284.
Dysclasite, 273.
Sphene, 360.
Pharmacolite, *Arsenate of Lime*, 189.
Roselite, 192.
Tungstate of Lime, 208.

GENUS 7. MAGNESIUM.

1. Combinations with soluble Acids.

Native Magnesia, *Hydrate of Magnesia*, 259.
Epsom Salt, *Sulphate of Magnesia*, 174.
Reussite, 174.
Nitrate of Magnesia, 176.
Magnesite, *Carbonate of Magnesia*, 198.
Hydromagnesite, *Hydrous Carbonate of M.*, 199.
Rhomb Spar, *Carbonate of Iron and Magnesia*, 198.
Boracite, *Biborate of Magnesia*, 347.
Wagnerite, *Phospho-fluate of M.*, 187.

2. Combinations with Silica.

Chrysolite, 335.
Nemalite, 259.
Talc, 260.
Kerolite, 255.
Serpentine, 253.
Picrosmine, 258.
Meerschaum, 256.
Nephrite, 287.
Schiller Spar, 264.
Bronzite, 265.
Hypersthene, 266.
Anthophyllite, 312.
Pyrallolite, 256.
Brucite, 348.
Pyroxene, 305.
Bucklandite, 308.
Hornblende, 309.
Cummingtonite, 312.
Mellilite, 302.

GENUS 8. ALUMINUM.

1. Alumina pure or hydrated, or combined with Bases.

Sapphire, *Pure Alumina*, 329.
Gibbsite, *Hydrate of A.*, 251.
Diaspore, *Dihydrate of A.*, 320.
Spinel, 327.
Automolite, 328.
Dysluite, 329.
Sapphirine, 331.

2. Combined with soluble Acids.

Solfatarite, *Sulphate of Alumina*, 170.
Websterite, *Tris-sulphate of A.*, 450.
Native Alum, *Sulphate of Potash and A.*, 169.
Alum Stone, 184.
Magnesia Alum, *Sulphate of M. and A.*, 170.
Ammonia Alum, *Sulph. Ammonia and A.*, 170.
Turquois, *Triphosphate of A.*, 289.
Wavellite, *Hydrous Diphosphate of A.*, 188.
Childrenite, 188.
Lazulite, 289.
Blue Spar, 290.
Amblygonite, 316.
Fluellite, *Fluorid of Aluminum*, 184.
Cryolite, 183.
Mellite, *Mellate of Alumina*, 438.

3. Simple Hydrous Silicates.

Halloylite, 250.
Allophane, 252.
Scarbroite, 251.
Pyrargillite, 251.

Kollyrite, 250.

4. *Compound Hydrous Silicates.*

Agalmatolite, 254.
Thomsonite, 269.
Edingtonite, 269.
Natrolite, 270.
Mesotype, 271.
Mesolite, 274.
Scolecite, 271.
Carpholite, 272.
Laumonite, 277.
Chabazite, 282.
Levyne, 283.
Analcime, 279.
Gmelinite, 283.
Stilbite, 268.
Epistilbite, 273.
Heulandite, 267.
Brewsterite, 274.
Harmotome, 277.
Phillipsite, 278.
Apophyllite, 276.
Comptonite, 275.

5. *Simple Anhydrous Silicates.*

Andalusite, *Disilicate of A.*, 317.
Bucholzite, *Anhydrous, Sil. of A.*, 321.
Kyanite, *Subsesquisilicate of A.*, 318.

6. *Compound Anhydrous Silicates.*

Topaz, *Silico-fluate of A.*, 333.
Sodalite, 280.
Nepheline, 291.
Idocrase, 350.
Garnet, 351.
Epidote, 313.
Withamite, 315.
Isopyre, 346.
Scapolite, 299.
Gehlenite, 301.
Prehnite, 286.
Iolite, 336.
Staurotide, 355.
Axinite, 337.
Turmaline, 322.
Fahlunite, 258.
Leucite, 281.
Elæolite, 292.
Margarite, 262.
Black Mica, 262.
Common Mica, 263.
Pinite, 257.
Pericline, 296.
Feldspar, 293.
Albite, 296.
Anorthite, 297.
Labradorite, 292.
Latrobite, 298.
Spodumene, 305.
Petalite, 288.

Genus 9. Glucinum.

Phenacite, *Silicate of G.*, 326.
Euclase, *Silicate of Alumina and G.*, 325.
Beryl, *Tersil. Alumina and G.*, 324.
Chrysoberyl, *Aluminate of G.*, 326.

Genus 10. Zirconium.

Zircon, *Silicate of Zirconia*, 353.
Sillimanite, *Sil. Alumina and Z.*, 320.
Æschynite, *Titanate of Cerium and Z.*, 368.
Eudialyte, 355.

Genus 11. Yttrium.

Xenotime, *Phosphate of Yttria*, 207.
Gadolinite, 367.
Yttro-Columbite, *Columbate of Yttria*, 370.
Fergusonite, 369.

Genus 12. Cerium.

Flucerine, *Fluorid of Cerium*, 205.
Subsesquifluorid of Cerium, 206.
Carbonate of Cerium, 206.
Cerite, *Silicate of C.*, 206, 364.
Thulite, 364.
Microlite, 207.
Yttrocerite, 207.
Allanite, 366.
Orthite, 366.
Pyrorthite, 366.
Pyrochlore, 362.

Genus 13. Thorium.

Thorite, 366.

Genus 14. Tellurium.

Native Tellurium, 395.
Herrerite, *Carbonate of Nickel and T.*, 246.

Genus 15. Arsenic.

Native Arsenic, 396.
White Arsenic, *Arsenous Acid*, 168.
Realgar, *Sulphuret of A.*, 434.
Orpiment, *Sesquisulphuret of A.*, 434.

Genus 16. Antimony.

Native Antimony, 395.
White Antimony, *Protoxyd of A.*, 209.
Gray Antimony, *Sesquisulphuret of A.*, 418.
Red Antimony, 430.

Genus 17. Molybdænum.

Molybdenite, *Bisulphuret of M.*, 425.

GENUS 18. TITANIUM.

Anatase, *Protoxyd of T.*, 361.
Rutile, *Titanic Acid*, 358.

GENUS 19. IRON.

1. *Pure, or combined with Oxygen.*

Native Iron, 386.
Magnetic Iron Ore, 383.
Specular Iron Ore, *Peroxyd of I.*, 381.
Brown Iron Ore, *Hydrous Perox. of I.*, 380.
Franklinite, 384.

2. *Combined with Sulphur or Arsenic.*

Iron Pyrites, *Bisulphuret of I.*, 406.
Magnetic Pyrites, *Sulphuret of I.*, 404.
White Iron Pyrites, 405.
Mispickel, 401.
Leucopyrite, 400.

3. *Combined with Oxygen Acids.*

Copperas, *Sulphate of Iron*, 177.
Botryogen, *Sulphate of Iron and M.*, 180.
White Copperas, *Bisulph. Perox. of I.*, 178.
Yellow Copperas, *Sulph. Perox. of I.*, 178.
Vivianite, *Phosphate of Iron*, 220.
Cacoxenite, 219.
Triphyline, 219.
Anglarite, 221.
Spathic Iron, } *Carbonate of I.*, 213, 215.
Junkerite,
Pyrosmalite, 222,
Hisingerite, 378,
Cronstedtite, 222,
Crocidolite, 378, } *Silicates.*
Yenite, 379,
Cummingtonite, 312,
Arfwedsonite, 313,
Cube Ore, *Subsesquarsenate of I.*, 217.
Arsenate of Iron, 218.
Scorodite, *Disarsenite of I.*, 218.
Chromic Iron, 377.
Wolfram, *Tungstate of Manganese and Iron*, 373.
Columbite, *Columbate of Iron*, 370.
Crichtonite, *Titanate of Iron*, 384.
Mohsite, 385.
Polymignite, 369.

GENUS 20. MANGANESE.

1. *Combined with Oxygen.*

Hausmannite, 373.
Braunite, *Anhyd. Sesquox. of M.*, 374.
Manganite, *Hydrous Sesquox. of M.*, 375.
Pyrolusite, *Anhyd. Bisox. of M.*, 376.
Wad. 377.
Psilomelanite, 374.
Varvacite, 377.
Newkirkite, 377.

2. *Combined with Sulphur or Arsenic.*

Manganblende, *Sulphuret of M.*, 429.
Arsenid of Manganese, 404.

3. *Combined with Acids.*

Diallogite, *Carbonate of M.*, 215.
Triplite, *Phosphate of Iron and M.*, 216.
Hetepozite, 216.
Huraulite, 217.
Manganese Spar, 302,
Troostite, 303, } *Silicates.*
Bustamite, 304,
Helvin, 348,

GENUS 21. ZINC.

1. *Combined with Oxygen.*

Red Zinc Ore, *Oxyd of Manganese and Z.*, 358.

2. *Combined with Sulphur or Selenium.*

Blende, *Sulphuret of Zinc*, 429.
Rionite, *Selenid of Zinc*, 428.

3. *Combined with Oxygen Acids.*

White Vitriol, *Sulphate of Zinc*, 179.
Calamine,, *Carbonate of Zinc*, 211.
Willemite, *Anhydrous Silicate of Zinc*, 212.
Electric Calamine, *Hydrous Sil. of Z.*, 212.
Hopeite, 213.

GENUS 22. NICKEL.

1. *Combined with Sulphur, Arsenic, or Antimony.*

Capillary Pyrites, *Sulphuret of N.*, 410.
Copper Nickel, *Arsenid of N.*, 399.
White Nickel, *Bisarsenid of N.*, 399.
Nickel Glance, *Arseno-sulphite of N.*, 400.
Antimonial Nickel, *Antimonid of N.*, 399.
Nickel Stibine, *Antimono-sulphite of N.*, 398.

2. *Combined with Oxygen Acids.*

Nickel Green, *Disarsenate of Nickel*, 245.

GENUS 23. COBALT.

1. *Combined with Sulphur or Arsenic.*

Cobalt Pyrites, *Sulphuret of C.*, 403.
Smaltine, *Bisarsenid of C.*, 402.

Terarsenid of C., 403.
Cobaltine, *Arseno-sulphite of C.*, 402.

2. *Combined with Oxygen Acids.*

Cobalt Vitriol, *Disulphate of C.*, 180.
Cobalt Bloom, *Disarsenate of C.*, 224.

GENUS 24. LEAD.

1. *Pure, or combined with Oxygen.*

Native Lead, 393.
Minium, *Sesquoxyd of Lead*, 235.

2. *Combined with Sulphur, Selenium, or Tellurium.*

Galena, *Sulphuret of Lead*, 422.
Clausthalite, *Selenid of Lead*, 423.
Cobaltic Galena, 423.
Foliated Tellurium, *Bitellurid of Lead*, 424.

3. *Combined with Chlorine.*

Cerasite, *Dichlorid of Lead*, 227.
Cotunnite, *Chlorid of Lead*, 227.

4. *Combined with Acids.*

Anglesite, *Sulphate of Lead*, 228.
Cupreous Anglesite, *Cupreous Sulphate of Lead*, 235.
Caledonite, 235.
Dyoxylite, 228.
Leadhillite, 227.
Corneous Lead, 226.
White Lead, *Carbonate of Lead*, 225.
Pyromorphite, *Phosphate of Lead*, 230.
Mimetene, *Arsenate of Lead*, 231.
Hedyphane, 229.
Chromate of Lead, 233.
Melanochroite, *Subsesquichromate of Lead*, 234.
Vauquelinite, *Cupreous Chromate of Lead*, 234.
Tungstate of Lead, 233.
Molybdate of Lead, 232.
Plumbo-Resinite, *Sexaluminate of L.*, 230.

GENUS 25. TIN.

Tin Ore, *Oxyd of Tin*, 363.
Tin Pyrites, *Cupreous Sulphuret of T.*, 411.

GENUS 26. COPPER.

1. *Pure, or combined with Oxygen.*

Native Copper, 394.
Red Copper Ore, *Red Oxyd of C.*, 362.
Black Copper Ore, *Black Oxyd of C.*, 446.

2. *Combined with Sulphur, Selenium, or Arsenic.*

Vitreous Copper Ore, *Disulphuret of Copper*, 414.
Variegated Copper Ore, 408.
Bournonite, 412.
Tennantite, 413.
Arsenid of Copper, 407.
Eucairite, 415.
Antimonial Copper, 415.
Gray Copper Ore, 411.

3. *Combined with Chlorine.*

Atacamite, *Chlorid of Copper*, 243.

4. *Combined with Oxygen Acids.*

Blue Vitriol, *Sulphate of C.*, 179.
Brochantite, 245.
Green Malachite, *Hydrous Dicarbonate of C.*, 237.
Blue Malachite, *Hydrous Carbonate of C.*, 237.
Libethenite, *Diphosphate of C.*, 242.
Pseudo-Malachite, *Subsesquiphosphate of C.*, 241.
Dioptase, *Sesquisilicate of C.*, 239.
Chrysocolla, 238.
Erinite, 240,
Copper Froth, 244,
Euchroite, 239,
Copper Mica, 244,
Olivenite, 242,
Aphanesite, 236,
Liroconite, 241,
} *Arsenates of Copper.*

GENUS 27. MERCURY.

Native Mercury, 392.
Native Amalgam, 392.
Cinnabar, *Sulphuret of M.*, 433.
Horn Quicksilver, *Dichlorid of M.*, 249.

GENUS 28. SILVER.

1. *Pure, or combined with Sulphur, Selenium, Arsenic, Antimony, or Molybdænum.*

Native Silver, 391.
Flexible Silver Ore, 425.
Vitreous Silver, *Sulphuret of S.*, 416.
Sternbergite, 425.
Polybasite, 417.
Stromeyerite, *Cupreous Sulphuret of Silver*, 415.
Brittle Silver Ore, 417.
Miargyrite, 431.
Dark Red Silver Ore, 431.
Light Red Silver Ore, 432.
Arsenical Silver, *Arsenid of S.*, 398.
Antimonial Silver, *Antimonid of S.*, 396.

Antimonial Sulphuret of S., 418.
Telluric Silver, *Bitellurid of Silver*, 416.
Graphic Tellurium, 416.
Molybdic Silver, 418.

2. Combined with Chlorine, or Iodine.

Horn Silver, *Chlorid of Silver*, 248.
Iodid of Silver, 249.

GENUS 29. URANIUM.

Pitchblende, 372.
Johannite, *Sulphate of U.*, 180.
Uranite, *Phosphate of Lime and Uranium*, 246.
Uranic Ochre, 246.

GENUS 30. PALLADIUM.

Native Palladium, 388.
Selenpalladite, *Selenid of P.*, 388.

GENUS 31. GOLD.

Native Gold, 389.
Aurotellurite, 390.

GENUS 32. PLATINUM.

Native Platinum, 387.

GENUS 33. IRIDIUM.

Iridium, 388.

CATALOGUE

OF

WORKS ON MINERALOGY.*

FOREIGN.

Plinii secundi, (Caii,) Naturalis Historia. First printed in large fol. at Venice, 1469. Numerous editions of this work have appeared since at various times and places.

Alberti Magni Philosophorum maximi de Mineralibus; Libri V. *Patavii*, 1476.

——— : De Mineralibus et rebus metallicis; Libri V. 8vo. 1541, 1569.

Agricola, G.: De Re metallica, Libri XI.; et de Natura fossilium, Libri X. Fol, *Basiliæ*, 1546. Reprinted at various times and places since.

Boetius de Boot: Gemmarum et Lapidum historia, quam olim edidit Ans. B. de Boot, postea Adrianus Tollins recensuit. Tertia Edit. longe purgatissima. Cui accedunt Jo. de Laet, de gemmis et lapidibus libri II., et Theophrasti liber de Lapidibus. 8vo. *Lugduni Batavorum*, 1647.

Libavii, (Andr.) Singularium libr. IV. quorum I. et III. de metallis lapidibus, et fossilibus. 8vo. *Francof.* 1549, also in 1601.

Encelius, Christ.: De re metallica: Libri III. 8vo. Francof. 1551; also in 1552 and 1557.

Theophrasti, (Eresii,) Opera omnia, Græce, cura Camotii edidit F. Turisanus. 8vo. *Venetiis*, apud Aldi filios, 1552. Various editions have appeared since.

Gesneri, (C.) De omni rerum fossilium genere, gemmis lapidibus, metallis, &c. 8vo. *Tiguri*, 1565.

Fabricius, G.: De metallicis rebus et nominibus obs. var. erud. quibus ea potissimum explicantur quæ G. Agricola præteriit. 8vo. *Tiguri*, 1566.

Cæsalpin, A.: De re metallica. 4to. *Romæ*, 1596.

Avicennæ Opera. *Romæ*, 1593. *Venetiis*, 1608.

Aldrovandi (Ulyssis) Opera Omnia. 13 vols. fol., with several thousand wood cuts. *Bononiæ*, 1599—1668.

Ferrante Imperator: De fossilibus opusculum. 4to. *Napoli*, 1610.

Cæsius, Bernardus: De Mineralibus, 650 pp. fol. *Lugduni*, 1636.

Laet, Jo. de: De Gemmis et Lapidibus, Lib. II. Gr. et Lat. Paris, 1647.

Lovell, Robert: Panzoologicomineralogia, or a history of animals and minerals. 12mo. *Oxford*, 1661.

Johnson, J.: Notitia regni mineralis, sive Catalogus subterraneorum cum præcipuis differentiis. 12mo. *Lipsiæ*, 1661.

Kircheri (Athanasii) Mundus subterraneus in Libros XII., digestus. 2 vols. in 1: with plates and portraits of Kircher and Pope Alexander, fol. *Amsterdam*, 1665.

Konig, Em.: Regnum Minerale, physice, medice, anatomice, chemice, investigatum, perscrutatum, erutum. 4to. *Basiliæ*, 1686; also in 1703.

Hiaerne, Urban: Kort Anledning til äskillige Malm och Bergarters, Mineraliers, etc.; eftersporjande och angifvande. *Stockholm*, 1694.

Gulielmini: De Salibus dissertatio physica, medico-mechanica. *Venetiis*, 1705.

Chambon: Traité des Metaux et des Minéraux. 12mo. *Paris*, 1714.

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* The following is an abstract of a more extended manuscript catalogue, collected from various sources by the author.

Henckel, J. Fr.: Pyritologia. 8vo. *Lipsiæ*, 1725.

———: Idea generalis de Lapidum origine. 8vo. *Dresd. et Lips.* 1734.

———: In Mineralogia redivivus. 8vo. *Dresdæ*, 1747.

Woodward, Dr. J.: Fossils of all kinds digested into a method suitable to their mutual relation and affinity. With plates. *London*, 1728.

———: An attempt towards the Natural History of the fossils of England, in the collection of J. Woodward. 2 vols. 8vo. *London*, 1729.

Bromel, Magn. von: Inledning til nödig Kundskap om Bergarter, Mineralier, Metaller, samt Fossilier. 8vo. *Stockholm*, 1730.

Swedenborgii (Emanuelis) Opera Philosophica et Mineralia. 3 vols. fol., with numerous plates. *Paris*, 1742.

Linnæus, C.: Systema Naturæ sive tria regna. Ed. I. fol. *Lugd. Bat.*, 1735. Ed. XII., *Holmiæ*, 1766.

Bouguet: Sur le formation des sels et des crystaux. 12mo. *Paris*, 1729.

D'Argenville, A. J. Desalliers: L'Histoire Naturelle éclaircie dans deux de ses parties principales, La Lithologie, et La Conchyliologie. Roy. 4to., with numerous plates. *Paris*, 1742.

Pott, J. H.: Chemische Untersuchungen, welche vornehmlich von der Litheognosie handeln. 4to. *Potsdam*, 1746; also 1751—54 and 1757.

———: Litheogeognosie, ou examen chymique des pierres et des Terres en general. *Paris*, 1753.

Wallerius, J. G.: Mineralogia eller Mineral Ricket indelt och beskrifvet. 8vo. *Stockholm*, 1747.

———: Lucubrationum academicarum specimen primum de systematibus mineralogicis et systemate mineralogico rite condendo. 8vo. *Holmiæ*, 1768.

———: Systema Mineralogicum, quo Corpora Mineralia in classes, ordines, genera et species, suis cum var. divisa describuntur atque observationibus, experimentis et figuris illustrantur. 2 vols. 8vo. *Vindob.* 1778.

Da Costa, E. Mendes: Natural History of Fossils. 4to. *London*, 1757.

Hill, Sir John: The History of Fossils. Fol. *London*, 1748.

Woltersdorf, J. L.: Systema minerale in quo regni mineralis producta omnia systematica per classes, ordines, genera, et species proponuntur. 4to. *Berlin*, 1738; also 1753—4 and 1755—8.

Cartheuser: Elementa Mineralogiæ systematice disposita. 8vo. *Francof.* 1755.

Salerne: L'Oryctologie. 4to. *Paris*, 1755.

Justi, J. H. G.: Grundriss des gesammten Mineralreichs. 8vo. *Göttingen*, 1757; also in 1765.

Cronstedt, Axel von: Försök til Mineralogia eller Mineral-rikets Uppställning. 8vo. *Stockholm*, 1758.

Bomare, Valmont de: Prospectus d'un cours sur l'histoire Naturelle des Minéraux. 12mo. *Paris*, 1759.

———: Mineralogie, ou nouvelle exposition du Regne Minérale. 8vo. *Paris*, 1762; also in 1769, 1774, 1780.

Gronovii, L. T.: Bibliotheca Regni Animalis et Lapidei. 4to. *Lugd. Bat.*, 1760.

Vogel, R. A. Praes.: Terrarum atque lapidum partitio, resp. A. Fr. Hempel. 4to. *Göttingen*, 1762.

Walch, J. E. J.: Das Steinreich systematisch entworfen. 2 vols. 8vo. 24 pl. *Halle*, 1762.

Bertrand, E.: Dictionnaire universel des fossiles propres et des fossiles accidentels, contenant une description des Terres Sables, &c. 8vo. 2 vols. in 1. *La Haye*, 1763.

———: Recueil de divers Traités sur l' Histoire Naturelle de la Terre et des Fossiles. 4to. *Avignon*, 1766.

Forster, J. R.: Classification of Fossils and Minerals. *London*, 1768; also in 1772.

Scopoli, J. A.: Einleitung zur Kenntniss und Gebrauch der Fossilien. 8vo. *Riga* und *Milan*, 1769.

———: Principia Mineralogiæ systematicæ et practicæ. *Pragæ*, 1772.

Lehman, J. A.: Entwurf, einer Mineralogie. 8vo. *Frankf.* et *Leip.* 1857; also in 1769 and 1791.

Bourguet: Du Regne Minerale. 4 vols. 12mo. *Paris*, 1771.

Romé de L'Isle: Essai de Cristallographie. 8vo. *Paris*, 1772. 2d ed. in 4 vols. 8vo. 1783.

Gerhard, C. A.: Beiträge zur Chemie und Geschichte des Mineralreichs. 2 vols. 8vo. *Berlin*, 1773—1776; also in 1781.

———: Grundriss des Mineralsystems. 8vo. *Berlin*, 1786 and 1797.

Sage: Mineralogie docimastique; with plates. 8vo. *Paris*, 1772; also in 2 vols. in 1777.
Schröter, J. S.: Journal für die Liebhaber des Steinreichs. *Weimar*, 1774.
Werner, Abr. G.: Von der ausserlichen Kennzeichen der Fossilien. 8vo. *Leip.*, 1774.
———: Letztes Mineral-system. 8vo. *Freyberg*, 1817.
Vogel, R. A.: Practisches Mineralsystem. 2d ed. 8vo. *Leip.*, 1776.
Fichtel, J. C. Von: Mineralgeschichte. 4to.; with plates. *Hamburgh*, 1780.
Lenz, J. G.: Tabellen über das gesammte Steinreich. 4to. *Jena*, 1781.
———: Mineralogisches Handbuch durch weitere Ausführung des Wernerschen Systems. 8vo. *Hildburghausen*, 1791.
———: Vollstandig Einleitung zur Kenntniss der Mineralien. 2 vols. 8vo. *Leipz.* 1794.
———: System der Mineralkörper. 8vo. *Bamberg* und *Wurzb.* 1800; also in 1809.
———: Erkenntnisslehre der Anorganischer Naturkörper. *Giesen*, 1813.
M. Buffon, Le Comte de: Histoire Naturelle des Minéraux. 4to. *Paris*, 1783.
Bergmann, T.: Sciagraphia regni mineralis secundum principia proxima digesti. 8vo. *Lipsiæ*, 1782.
Faujas de Saint Fond, B: Minéralogie des Volcans ou Description de toutes les substances produits ou rejetées par les feux souterrains. Royal 8vo. *Paris*, 1784.
Kirwan, R.: Elements of Mineralogy. 8vo. *London*, 1784; 2d ed., 1794.
Daubenton: Tableaux méthodique des Minéraux suivant leurs differentes natures. 4to. *Paris*, 1784.
Well, J. J. von: Methodische Einleitung der mineralogischen Körper. 8vo. *Wien.* 1786.
Cavallo, Tib.: Mineralogical Tables; fol. *London*, 1786.
Schöpf, J. D.: Beyträge zur Mineralogischen Kenntniss des östlichen Theils von Nordamerika, und seiner Gebirge. 8vo. 1787.
Walker: Classis Fossilum, sive characteres Naturales chymici classium et ordinum in Systemate Minerali. 8vo. *Edinburg*, 1787.
Fibig: Handbuch der Mineralogie. 8vo. *Mainz* und *Frankf.*, 1787.
Volta, Ab.: Elementi di Mineralogia analitica e sistematica. 8vo. *Pavia*, 1787.
Batsch, A. J. G. K.: Versuch einer Anleitung zur Kenntniss und Geschichte der Thiere und Mineralien. 2 Bde. 8vo. *Jena*, 1788, 1789; also 1796—1800.
Williams, John: Natural History of the Mineral Kingdom. 2 vols. 8vo. *Edinb.*, 1789.
Schall, C. F. W.: Anleitung zur Kenntniss der besten Bücher in der Mineralogie. 2d edit. 8vo. *Weimar*, 1789.
De Born: Catalogue de la collection des Fossiles de Eleonore de Raab. 2 vols. 8vo. *Vienna*, 1790.
Suckow: Anfangsgründe der Mineralogie. 8vo. *Leipzig*, 1790; 2d ed. 2 vols. 8vo. 1803—4.
Gallitzin, Le Prince Dimitri de: Traité ou Description abrégée méthodiques des Minéraux. 4to. *Maestricht*, 1792.
Karsten, D. L. G.: Tabellarische Uebersicht der mineralogischen einfachen Fossilien. 8vo. 2te Aufg. *Berlin*, 1792; also 1800, 1808.
Klaproth, Martin Heinrich: Beyträge zur Chemischen Kenntniss der Mineralkörper. 3 B. 8vo. *Berlin*, 1795—1802.
Emmerling, L. A.: Lehrbuch der Mineralogie. 8vo. *Giezen*, 1793.
Veltheim, A. V. von: Reformen in der Mineralogie. 8vo. *Helm.*, 1793.
Schmeisser, J. G.: System of Mineralogy. Vol. 1. 8vo. *London*, 1794.
Wiedenmann: Handbuch der Oryktognostichen Theils der Mineralogie. 2 vols. 8vo. *Leipzig*, 1794.
Del Rio, Don Andres Manuel: Elementos de Oryktognosia ò del conocimiento de los fosiles, dispuestos segun los principios de A. G. Werner. 4to. *Mexico*, 1795.
———: Nuevo sistema Minerale. *Mexico*, 1827.
Retzius, A. J.: Försök til Mineral-Rikets Upställning. 8vo. *Lund*, 1795.
Forster, J. R.: Onomatologia nova systematis oryktognosiæ, vocabulis latinis expressa. Fol. *Halæ*, 1795.
Babington: A Systematic Arrangement of Minerals. 4to. *London*, 1795; 1799.
Struve, H.: Méthode Analytique des Fossiles, fondée sur leurs Caractères Exterieurs. 8vo. Lausanne, 1797; 8vo. *Paris*, 1798.
Napione: Elementi di Mineralogia. 1 vol. 8vo. *Turin*, 1796.
Townson, R.: Philosophy of Minéralogy. 8vo. plates. *London*, 1798.
Reuss, F. A.: Lexicon Mineralogicum, sive Index Latino-Gallico-Suecico-Danico-Anglico-Russico-Hungarico-Germanicus Mineralium. 8vo. Cura Regis. *Leip.* 1798.

Reuss, F. A.: Lehrbuch der Mineralogie nach Karsten's Tabellen. 8vo. *Leipzig*, 1801—1806.
Jameson, Robert: Mineralogy of the Scottish Isles. Maps and plates; 2 vols. 4to. *Edinburgh*, 1800.
———: System of Mineralogy. 2 vols. pl. 8vo. *Edinburgh*, 1804; 2d ed. 1816; 3d ed. 1818.
———: A Treatise on the External Characters of Minerals. 8vo. *Edinburgh* and *London*, 1804—1805.
Brunner, J.: Versuch einer neuen Systems der Mineralogie. 8vo. *Leipzig*, 1800.
Haüy, L' Abbé: Traité de Minéralogie. 3 vols. 8vo. *Paris*, 1801—2.
———: Tableau comparatif des résultats de la Cristallographie et de l' analyse chimique, relativement à la classification des minéraux. 8vo. figs. *Paris*.
———: Traité des caractères physique des pièrres. 8vo. figs. *Paris*, 1817.
———: Traité de Crystallographie. 2 vols. 8vo. *Paris*, 1822.
———: Traité de Mineralogie. 4 vols. 8vo. *Paris*, 1822.
Brochant de Villiers, A. J. M.: Traité élémentaire de Minéraux suivant les principes de Werner. 2 vols. 8vo. *Paris;* also 1807.
———: Sur la cristallisation geometriquement et physiquement considerée. With numerous plates. 8vo. *Strasburg*, 1819.
Hoff, A. von: Magazin fur die gesammte Mineralogie, &c., pl. 8vo. *Leipz.*, 1801.
Mawe: Mineralogy of Derbyshire. 8vo.; plates. *London*, 1802.
Sowerby: British Mineralogy. 8vo. *London*, 1802—1817.
Dolomieu, D. de: Sur la Philosophie Minéralogique et sur l'espéce Mineralogique. 8vo. *Paris*, 1802.
Hausmann, J. F. L.: Krystallogische Beitrage. 4to. Pl. 1803.
———: Untersuchungen uber die Formen der leblosen Natur Ir. Bd. 4to. mit vielen Kupfern. *Göttingen*, 1821.
———: Entwurf eines Systems der unorganisirten Naturkörper. 8vo. *Cassel*, 1809.
———: Handbuch der Mineralogie. 3 vols. 8vo. *Göttingen*, 1813; 2d edit. 1828.
Ludwig, C. F.: Handbuch der Mineralogie nach A. G. Werner. 8vo. *Leipzig*, 1803.
Lucas, J. A. H.: Tableau Méthodique des espèces minerales. 8vo. *Paris* and *Strasb.*, 1803.
Schwarz, G. M.: Handbok i Oryktognosien. 8vo. 1803.
Launnas, L. de: Minéralogie des Anciens. 2 vols. 8vo. *Bruxelles* and *Paris*, 1803.
Rozin: Essai sur l' étude de la Minéralogie. 8vo. 368 pp. *Bruxelles*, 1803.
Mohs, Friederich: Handbuch der Oryktognosie. 3 vols. 8vo. *Wien*, 1804.
———: Die Charaktere der Classen, Ordnungen, Geschlechten und Arten, oder die Charakteristik der naturhistorischen Mineralsystems. 8vo. *Dresden*, 1821.
———: Der Naturgeschichte des Mineralreichs. *Wien*, 1832.
Accum, F.: Elements of Crystallography, after the manner of Haüy. 8vo. plates. *London*, 1804.
———: Analysis of Minerals. 12mo. *London*, 1804.
———: Manual of Analytical Mineralogy. 2 vols. pl. *London*, 1808.
———: System of Mineralogy and Mineralogical Chemistry. 4 vols. 8vo. *London*, 1810.
Haberle, C. C.: Beiträge zu einer allgemeinen Einleitung in das Studium der Mineralogie. 8vo. *Weimar*, 1805.
———: Characterisirende Darstellung der Mineralien mit Hinsicht auf Werner et Haüy's beobachtungen. 8vo. *Weimar*, 1806.
Leonhard, C. C., R. F. Menz, und J. H. Kopp: Systematisch-Tabellarische Uebersicht und Characteristik der Mineralkörper. 2 vols. fol. *Frankfort*, 1806; 2d edit. 1817.
———: Taschenbuch für die gesammte Mineralogie mit Hinsicht auf die neueste Entdeckungen. 8vo. 1807.
———: Handbuch der Oryctognosie. 8vo. *Heidelberg*, 1821; 2d edit. 1826.
Lucas, J. A. H.: Tableau Méthodique des Espèces Minérales. 8vo. *Paris* 1806—13.
Brongniart, Alex.: Introduction à la Minéralogie. 8vo. *Paris*, 1807; 2d ed. in 1824.
Brard, C. P.: Manuel du Mineralogiste, 12mo. *Paris*, 1808; 2d edit. 1824.
———: Minéralogie appliquée aux arts. 3 vols. 8vo. *Paris*, 1821.
———: Description historique de sa collection de Minéralogie appliquée aux arts. 8vo. *Paris*, 1833.
Kidd, J.: Outlines of Mineralogy. 2 vols. 8vo. *Oxford*.
Weiss: De indagando formarum crystallinarum charactere geometrico principali. *Lipsiæ*, 1809.

Nüzlein, F. A.: Versuch eine neuen Systems der mineralogisch-einfachen Fossilien. *Bamberg* und *Wurzburg*, 1810, 1812.

Hoffmann, C. A. E.: Handbuch der Mineralogie mit Fortsetzung von A. Breithaupt. 4 vols. *Freyberg*, 1811—1818.

Chenevix, R: On Mineralogical Systems. 8vo. *London*, 1811.

Steffens: Vollstandiges Handbuch der Oryktognosie, 4 vols. 8vo. *Halle*, 1811—1824.

Bournon, Comte de: Catalogue de sa collection Minéralogique. 8vo., with 4to. plates. 1813.

———: Traité complète de la chaux carbonatée, et de l' Arragonite. 3 vols. 4to. *London*, 1808.

Aiken, Arthur: Manual of Mineralogy. 8vo. *London*, 1814.

Allan: Mineralogical Nomenclature. 8vo. *London*, 1814.

Gravenhorst, J. L. C.: Handbuch der Anorganognosie. 8vo. *Leipzig*, 1815.

Berzelius, J. J.: Versuch durch Anwendung der elektrisch chemischen Theorie und der chemischen Verhältnisslehre, ein rein wissenschaftliches System der Mineralogie zu begründen. Aus dem Schwed. von Dr. A. F. Gehlen. 8vo. *Nürnberg*, 1815.

———: Neues System der Mineralogie, aus dem Schwedischen von Dr. Gmelin und Pfaff. 8vo. *Nürnberg*, 1816.

———: Von der Anwendung des Löthrohrs in der Chemie und Mineralogie; Aus der Handschrift ubersetzt von Heinr. Rose. 8vo. *Nürnberg*, 1821.

———: The same, translated by J. G. Children. 8vo. 3 pl. *London*, 1822.

Tondi: Elementi di Orittognosia. 2 vols. 8vo. *Napoli*, 1817.

Phillips, Wm.: Outlines of Mineralogy and Geology. 3d edit. 8vo. *London*, 1818; 4th edit. 1826.

———: An elementary introduction to the knowledge of Mineralogy. 8vo. *London*, 1823.

Bakewell, R.: Introduction to Mineralogy. 8vo. *London*, 1819.

Kick, Z. Tentamen Mineralogicum, seu Mineralium nova distributio in classes, ordines, genera, &c. 8vo. *Bruxelles*, 1821.

Koratz, Michel: Lexicon Mineralogicum enneaglottum. 8vo. *Pest*. 1821.

Neumann: Beiträge zur Kristallonomie. 8vo. *Berlin*, 1823.

Kosk, M. F.: Beiträge zur Kenntniss krys tallin Huttenproducte. 8vo. *Göttingen*, 1823.

Breithaupt, A.: Vollstandige Charakteristik des Mineral-systems. 8vo. *Dresden*, 1823.

———: Physiologie der Unorganischen Natur. 8vo. pl. *Dresden*, 1828.

Renier, S. A.: Elementi di Mineralogia. 8vo. *Padua*, 1823.

Beudant, F. S.: Traité élémentaire de Minéralogie. 8vo. plates. *Paris*, 1834. 2d edit. in 2 vols. 8vo. 1830.

Stchégloff, N.: Mineraloguia po sistémiè Gospodinda Haüy. 2 vols. 8vo. *St. Petersburg*, 1824.

Haidinger, Wm.: Treatise on Mineralogy, or the Natural History of the Mineral Kingdom; translated from the German of Mohs. 3 vols. 8vo. *Edinburgh*, 1825.

Monticelli and Covelli: Atlante della Mineralogia Vesuviana. 19 pl *Napoli*, 1825.

Blondeau: Manuel de Mineralogia. 18mo. *Paris*, 1825; 2d edit. 1828.

Marx, Dr. C. M.: Geschichte der Krystallkunde. 8vo. *Carlsruhe* und *Baden*, 1825.

Naumann, C. Fr.: Entwurf der Lithurgik oder ökonomischen Mineralogie. 8vo. *Leipzig*, 1826.

———: Grundriss der Krystallographie. 8vo. *Leipzig*, 1826; 2d edit. 2 vols. 1830.

———: Lehrbuch der Mineralogie. 8vo. *Berlin*, 1828.

Rau, Ambros: Lehrbuch der Mineralogie. 8vo. *Wurzberg*, 1826.

Girardin et Lecoq: Elémens de Minéralogie appliquée aux science chimique. 2 vols. 8vo. pl. *Paris*, 1826.

Drapiez: Minéralogie Usuelle. 504 pp. 12mo. *Paris*, 1826.

Bredsdorf, J. H.: De notione speciei in regno minerali. 104 pp. 12mo. *Copenhagen*, 1827.

Desnos, J. O.: Precis de Minéralogie Moderne. 2 vols. 32mo. pl. formant 20 and 21 livr. de l'Encyclopédique portative. *Paris*, 1827.

Glocker, Dr.: Grundriss der Mineralogie. 8vo. *Breslau*, 1827.

———: Uebersicht der Krystallisations-systeme, etc. 48 pp. 4to. *Breslau*, 1829.

———: Handbuch der Mineralogie für Vorlesungen und zum Privategebrauch bestimmt. 1829.

———: Handbuch der Mineralogie. 2 vols. 8vo. pl. *Nürnberg*, 1831.

Bernhardi: Beiträge zur Kenntniss der Cristallformen. *Erfurt*, 1827.

Hartmann, C. F. A.: Mineralogie. 8vo. pl. *Ilmenau*, 1828; also in 1834.
———: Repertorium der Mineralogie. 8vo. pl. *Leipzig*, 1834.
———: Grundzüge der Mineralogie und Geologie. 8vo. *Nürnberg*, 1835.
Freisleben, J. Ch.: Magazin fur die Orictographie von sachsen. 8vo. *Freiberg*, 1828.
Grasman, J. Gunter: Zur physischen Krystallonomie, und geometrischen Combinationslehre. in 8vo. 184 p. 3 pl. *Stettin*, 1829.
Frankenheim, M. L: De Cristallorum cohæsione. *Breslau*, 1829.
———: Die Lehre von der Cohäsion, umfassend die Elasticität der Gase, die Elasticität und Cohärenz der flussigen und sesten Korper und die Krystallkunde. 502 pp. 8vo. *Breslau*, 1835.
Haidinger, Wm.: Anfangsgrunde der Mineralogie. 15 pl. *Leipzig*, 1829.
Kobell, Frantz von: Charakteristik der Mineralien. *Nürnberg*, 1831.
———: Tafeln zur Bestimmung der Mineralien, etc. 4to. *Munich*, 1833.
Hessel: Crystallometrie. *Leipzig*, 1831.
Kupffer: Handbuch der rechnenden Kristallonomie. 4to. 14 pl. *St. Petersburg*, 1831.
Karsten, Dr. C. J. B.: System der Mineralogie geschichtlich statistisch, theoretisch und technisch. 5 vols. 8vo. and royal folio atlas, containing 51 plates. *Berlin*, 1831.
Walchner: Handbuch der gesammte Mineralogie. 1104 pp. 8vo. *Carlsruhe*, 1832.
Presl: M. K. B.: Anleitung zum Selbststudium der Oryctognosie. 8vo. *Prague*, 1833.
Catullo: Elementi de Mineralogia applicata alla medicina e alla farmacia. 2 vols. 8vo. *Padua*, 1833.
Rose, M. Gustav: Elemente der Krystallographie. 8vo. 10 pl. *Berlin*, 1833.
Uhde: Versuch einer genetischen Entwickelung, &c. *A Philosophical Essay on the Mechanical Laws of Crystallization.* 8vo. 4 pl. *Brême*, 1833.
Prestel, A. E.: Anleitung zur perspective Entwerfung, &c. *On the Perspective projection of Crystalline forms.* 8vo. pl. *Göttingen*, 1833.
Allan, Robert: A Manual of Mineralogy. 350 pp. 8vo. *Edinburgh*, 1834.
Suckow, M. G.: Grundriss der Mineralogie. 8vo. *Darmstadt*, 1834.
Richard, A.: Précis élémentaire de Minéralogie. 8vo. pl. *Paris*, 1835.
Necker: Le regne minéral ramené aux méthodes de l' histoire naturelle. 2 vols. in 8vo. of above 400 pages each. *Paris*, 1835.
Thomson, Thomas: Geology and Mineralogy, forming the third portion, or the fourth and fifth volumes of his System of Chemistry. 2 vols. 8vo. *London*, 1835.
Kurr: Grundzüge der ökonom-techischen Mineralogie. 8vo. 1836.
Hochsteller: Populäre Mineralogie. 12 pl. 8vo. 1836.
Karsten's Archiv für Mineralogie. 8vo. *Berlin.*
Glocker: Mineralogischen Jahreshefte. 8vo. *Breslau.*
Hartmann: Jahrbuch der Mineralogie, Geologie, &c. 8vo.
Leonhard und Bronn: Neues Jahrbuch fur Mineralogie, Geographie, Geologie und Petrefaktenkunde. 8vo.

AMERICAN.*

B. Silliman: Mineralogy and Geology of New Haven, in a statistical account of the city of New Haven, by Pres. Timothy Dwight, published by the Connecticut Academy of Arts and Sciences. pp. 5—15. 8vo. *New Haven*, 1811.
*A. Aikin: Manual of Mineralogy. 12mo. *Philadelphia*, 1815.
*Wm Phillips: Outlines of Mineralogy and Geology. 12mo. *New York*, 1817.
*———: Elementary Introduction to the Knowledge of Mineralogy, with notes and additions on American Articles, by Samuel L. Mitchill. 12mo. *New York*, 1818.
Parker Cleaveland: Elementary Treatise on Mineralogy and Geology. 670 pp. 8vo. *Boston*, 1816; 2d edit. in 2 vols. 8vo. *Boston*, 1822.
James Freeman Dana: Outlines of the Mineralogy and Geology of Boston and its environs. 8vo. *Boston*, 1818.

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* Reprinted foreign works are indicated by an asterisk.

*Thomas Thomson: System of Chemistry, in 4 vols. 8vo., the 3d containing a Treatise on Mineralogy. Edited by Thomas Cooper, from the 5th London edition. *Philadelphia*, 1818.

Henry R. Schoolcraft: A view of the Lead Mines of Missouri, including observations on the Mineralogy, Geology, Geography, &c. of Missouri and Arkansaw, and other portions of the Western Country. 2 plates. 300 pp. 8vo. *New York*, 1819.

Thaddeus M. Harris: The Natural History of the Bible, or a description of all the quadrupeds, birds, fishes, &c., precious stones, &c., mentioned in the Bible. 476 pp. 8vo. *Boston*, 1820.

*Delvalle Lowry: Conversations on Mineralogy and Geology. *Philadelphia*, 1822. Reprint from the last London edition.

Webster: Catalogue of Minerals in the State of New-York. 12mo. *Albany*, 1824.

Frederick Hall: Catalogue of Minerals found in the State of Vermont, and in the adjacent States. 44 pp. 8vo. *Hartford*, 1824.

Samuel Robinson: Catalogue of American Minerals with their localities, arranged in the order of the States. 8vo. 316 pp. *Boston*, 1825.

Ebenezer Emmons: Manual of Mineralogy and Geology. 230 pp. 12mo. *Albany*, 1826; 2d edit. 299 pp. 12mo. *Albany*, 1832.

J. L. Comstock: Elements of Mineralogy, adapted to the use of Seminaries and private students. lxxvi and 338 pp. 8vo. *Boston*, 1827; 2d edit. 12mo.

James Macauley: A sketch of the Geology and Mineralogy of the State of New York. pp. 281—362, in a work entitled, "The Natural, Statistical, and Civil History of the State of New York, by James Macauley." 3 vols. 8vo. *New York*, 1829.

Ebenezer Baldwin: Annals of Yale College, in New Haven, Connecticut. 8vo. *New Haven*, 1831. Contains a sketch of the Geology and Mineralogy of the vicinity of Yale College.

Proposals of the Phenix Mining Company, with a statement of the History and Character of their Mines in Granby, Conn. 30 pp. 8vo. *New York*, 1831.

C. T. Jackson and Francis Alger: Remarks on the Mineralogy of Nova Scotia. 1 pl. 115 pp. 8vo. *Cambridge, Mass.*, 1832.

C. Andres Del Rio: Elementos de Oryctognosia. 8vo. *Philadelphia*, 1832.

Charles Upham Shepard: Treatise on Mineralogy. 1st part one vol. 12mo. *New Haven*, 1832. 2d part consisting of descriptions of the species, and tables illustrative of their Natural and Chemical affinities. 2 vols. 12mo. with 500 wood cuts. *New Haven*, 1835.

Jane Kilby Welsh: Familiar lessons in Mineralogy and Geology, designed for the use of young persons and Lyceums. 2 vols. 12mo. *Boston*, 1833.

Edward Hitchcock: Report on the Geology, Mineralogy, Botany, and Zoology of Massachusetts, made and published by order of that State. 700 pp. 8vo. *Amherst*, 1833.

William W. Mather: Sketch of the Geology and Mineralogy of New London and Windham Counties, in Connecticut. 36 pp. 8vo. with a map. *Norwich*, 1834.

N. F. Moore: Ancient Mineralogy, or an Inquiry respecting Mineral Substances mentioned by the Ancients. 192 pp. 12mo. *New York*, 1834.

Jacob Porter: Topographical Description and Historical Sketch of Plainfield, in Massachusetts. 44 pp. 8vo. *Greenfield*, 1834.

*J. M. Moffatt: Mineralogy and Crystallography; pp. 236—298 of the Scientific Class Book. Reprinted with additions from the London edition, by Walter R. Johnson. 12mo. *Philadelphia*, 1836.

Abraham Gesner: Remarks on the Geology and Mineralogy of Nova Scotia. 8vo. 272 pp. *Halifax*, 1837.

ARTICLES IN AMERICAN JOURNALS.

Columbian Magazine, for March, 1788. *Philadelphia.*
B: On the Ores and Fossils of America. 3½ pp. With a plate.

The Medical Repository, edited by Samuel L. Mitchill and Edward Miller. 8vo. *New York*, 1798—1812. New Series, 1812—1823.

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The American Medical and Philosophical Register, edited by David Hosack and John W. Francis. 8vo. *New York*, 1810—1814.

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American Mineralogical Journal: Conducted by Archibald Bruce, M. D. 8vo. *New York*, 1810.

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* This number of volume xxxii. appeared too late for an insertion of this species in the preceding part of this treatise. The following are its characters:

Primary form: an obtuse oblique rhombic prism; M : M=95° (common goniometer,) P : M=100° 1 *Secondary form:* the primary with the acute lateral edges deeply truncated—M : ē (truncating plane)=137° 30′; also the primary with the terminal edges replaced, forming a four sided pyramid at each extremity of the crystal. Surface generally not very smooth, but nearly of the same quality on the different faces. *Cleavage* parallel with the bases, sometimes distinct, but commonly uneven; parallel with the longer diagonal, very perfect.

H.=4·5. G.=4·2—4·6. *Lustre* vitreous to adamantine. *Streak* white. *Color* hyacinth-red. Transparent—translucent.

According to the analysis of Prof. C. U. Shepard, it contains Protoxyd of Cerium 56·53, Phosphoric Acid 26·66, Zirconia 7·77, Alumina 4·44, Silica 3·33=98·73. It is mainly therefore a *sesquiphosphate of the protoxyd of cerium.* Alone before the blowpipe, in very thin fragments, it loses its red color, becoming pearl-gray, with a tinge of yellow, and fuses with great difficulty on the edges, into a transparent glass. With borax, in minute fragments, it turns white, and gradually dissolves, forming a globule which is bright yellowish-green while warm, but colorless when

Boston Journal of Philosophy and the Arts. 8vo. 1824—6.

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Monthly American Journal of Geology and Natural Science, conducted by G. W. Featherstonhaugh. 8vo. 1831—1832. *Philadelphia.*

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American Philosophical Transactions. 4to. *Philadelphia*, 1771—

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Memoirs of the American Academy. 4to. *Cambridge*, 1785—

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cold. Pulverized, it is very slightly acted upon by aqua regia. A small quantity placed on platinum foil, and moistened with sulphuric acid, tinged the blowpipe flame green.

Obs. Edwardsite occurs disseminated through Sillimanite, in gneiss, at the falls of the Yantic, in Norwich, Conn., where it is associated with individuals of red feldspar, black mica, and occasionally small crystals of blue corundum.

The crystals are rarely above one third of an inch in length, by one sixth in breadth. The deep truncations of the acute lateral edges, impart to the larger prisms a flattened appearance. The minute crystals, with pyramidal extremities, exhibit but little alteration from the primary prism. The terminations of the larger crystals are usually incomplete; occasionally they present a cross cleavage, in which case the lateral faces are horizontally striated. The angle P : M was obtained from a cleavage plane, and is considered only as an approximation. The crystals have a close resemblance to zircon.

This species evidently falls within the Genus Spanialus, Order Barytinea, and may be designated from its crystalline form *Spanialus obliquus.* It was named Edwardsite, in compliment to Gov. H. W. Edwards.

Vol. III.—1809.
S. Godon: Mineralogical Observations made in the environs of Boston, in the years 1807 and 1808.

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Memoirs of the Connecticut Academy of Arts and Sciences. 8vo. *New Haven.*
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Journal of the Academy of Natural Sciences of Philadelphia. 8vo. *Philadelphia,* 1817—

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Annals of the Lyceum of Natural History of New York. 8vo. *New York*, 1824—

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Contributions of the Maclurean Lyceum to the Arts and Sciences. 8vo. *Philadelphia*, 1827.

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Transactions of the Geological Society of Pennsylvania.

Vol. I.—1833—1835.

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———: Native Iron from Penn Yan, Yates Co., N. Y., p. 358.

Transactions of the Albany Institute. 8vo. *Albany.*

Vol. I.—1831.

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Boston Journal of Natural History. 8vo. ***Boston.***

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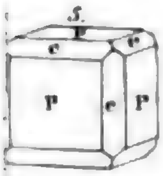
ERRATA.

Page 58, note, 4th line from bottom, for *Haire*, read *Haüy*.
" 81, line 4, omitted after magnet: "A magnetic needle, balanced on a pivot, affords a far more delicate test of the magnetic susceptibilities of a mineral."
Page 85, 8th line from bottom, for *hackley*, read *hackly*.
" 96, 9th line from top, for *minerals*, read *animals*.
" 147 and 183, for *oxalate of lime*, read *oxalate of iron*.
" 149, note, 3d line from bottom, for *minerals*, read *metals*.
" 150 and 216, for the systematic name of *Hetepozite*, read *M. Dufrenæi*.
" 150, for, Genus 8, *Aræalus*, read *Arealus*.
" 153, 14th line from bottom, for *Brewsterianus*, read *Breusterianus*.
" 200, for *Barytes rubefaciens*, read *Baralus rubefaciens*.
" 204, fig. 2, for ĕ, read é′, and for ŏ, read *o*.
" 211, 22d and 23d lines from top, transpose *oxyd of zinc* and *carbonic acid*.
" 220, for ā, in the upper part of the figure, read ă.
" 222, 16th line from top, for *sesquoxyd of iron*, read *sesquoxyd of manganese*.
" 229, 30th line from top, for *Luzerne*, read *Louisa*.
" 284, 12th line from bottom, for *e* read ē.
" 295, 30th line from top, for *composition*, read *constituents*.
" 324, lines 20 and 21 from bottom, for a, a′, a″, read e, e′, e″.
" 373, figure, for *a*, read ĕ.

APPENDIX A.

Page 7, 6th line from bottom, in the value of tan. ξ, for $b-a$ cos. ρ, read $a-b$ cos. ρ.
" 7, last line, for $1+\tan.\ \upsilon-\tan.\ \upsilon'$, read $1+\tan.\ \upsilon\ \tan.\ \upsilon'$.
" 16, § 19, prefix the negative sign to the values of cos. X, cos. Y, cos. Z.
" 17, in the denominator of the first deduced value of cos. U, for $\gamma'^2\delta'^2$, read $\gamma'^2\alpha'^2$.
" 20, for the denominator of the first value of cos. U, substitute
$$\surd(\alpha^2\delta^2+\beta\ \delta^2+\alpha^2\gamma^2-2\alpha\beta\delta^2\cos.\rho)\surd(\alpha'^2\delta'^2+\beta'^2\delta'^2+\alpha'^2\gamma'^2-2\alpha'\beta'\delta'^2\cos.\rho).$$
" 28, in the value of cos. A'', for $m^2(n^2+1)+m^2$, read $m^2(n^2+1)+n^2$.
" 29, § 35, *b*, in the first value of cos. Q'', for $m\ n'$, read $m\ m'$.
" 31, § 36, *d*, 3, for $m'=n+1$, read $m'=n-1$.
" 32, § 37, *b*, 1, for $m'=n$, read $n'=n$.
" 33, § 38, *b*, opposite $\frac{O}{2}$, for $m(m+1)$, read $m''(m+1)$.
" 39, 12th line from top, for $m^2a^2(n^2+1)+n^2$, read $\surd(m^2a^2(n^2+1)+n^2)$.
" 39, dele the negative sign before the values of cos. sin. and tan. of $\frac{1}{2}X$, $\frac{1}{2}Y$, $\frac{1}{2}Z$.
" 40, 3d and 4th lines from top, for ∞On, read ∞Pn.
" 40, § 48, 2, for a cos. $\frac{1}{2}Z$, read a cot. $\frac{1}{2}Z$.
" 41, § 49, 5th line from bottom, for cos. Z, (§ 46,) read cos. T, (§ 46.)
" 42, § 50, *b*, transfer $mP\infty$ from 2 to 3.
" 43, § 52, for $m'a^2$, in the denominator of the value of cos. Q, read m^2a^2.
" 43, in the table opposite mP and $mP\infty$ and under $0P$, for $\surd(2m^2a^2+1)$ and $\surd(m^2a^2+1)$, read $\frac{1}{\surd(2m^2a^2+1)}$ and $\frac{1}{\surd(m^2a^2+1)}$.
" 43, opposite mP, and under $\infty Pn'$ for n^2, in the numerator, read n'.
" 55, § 63, *b*, 2, for $\frac{1}{2}m'(3n'+1)=m$, read $\frac{1}{2}m'(3n'-1)=m$.
" 56, § 65, opposite $m'P2$, for $\surd(m'^2a^2+1)$, read $\frac{1}{\surd(m'^2a^2+1)}$.
" 56, 4th line from bottom, for $mm'a^2(3n\mp1)\mp3$, read $mm'a^2(3n\mp1)\pm3$.
" 62, 14th line from top, for cos. $\beta=\cot.\ \frac{1}{2}Y\tan.\gamma$, read cos. $\beta=\cot.\ \frac{1}{2}Y\cot.\gamma$.
" 63, § 74, 2d line, for $m'\bar{P}n'$, read $m'\breve{\bar{\bar{P}}}n'$.
" 63, § 75, 3, for $\frac{2mm'}{m+m'}\breve{P}$, read $\frac{2mm'}{m+m'}\breve{P}\infty$.
" 68, 13th and 14th line from top, from X, Y, X', Y', dele Y, Y'.

5.



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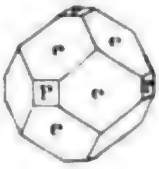

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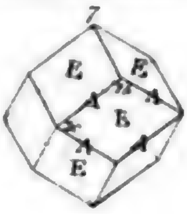

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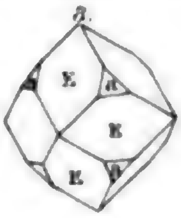

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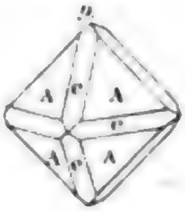

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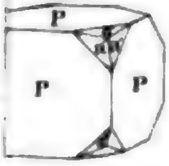

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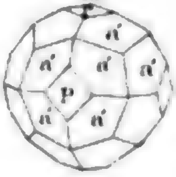

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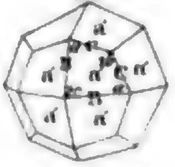

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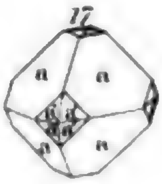

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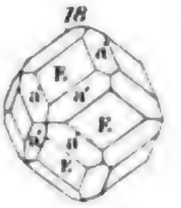

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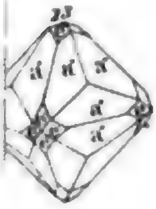

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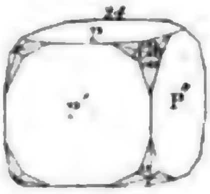

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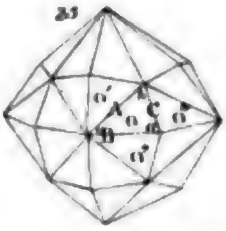

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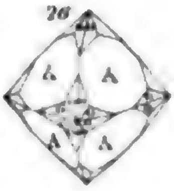

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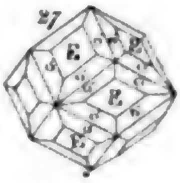

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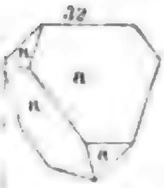

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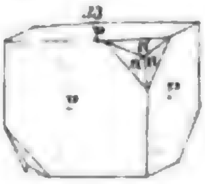

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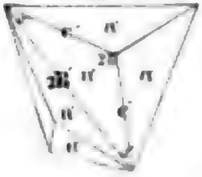

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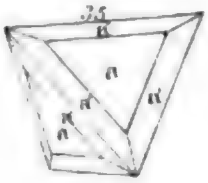

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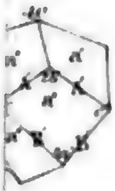

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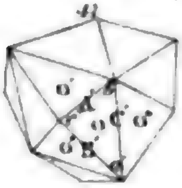

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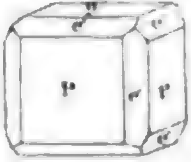

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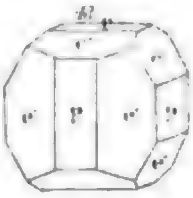

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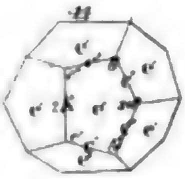

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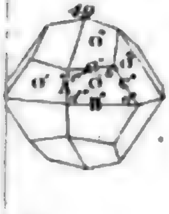

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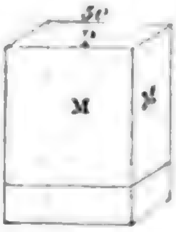

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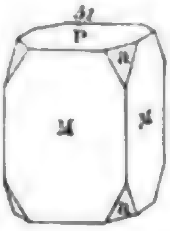

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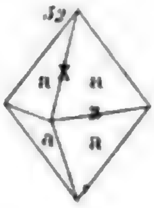

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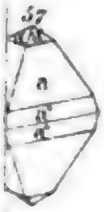

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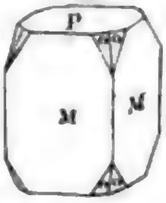

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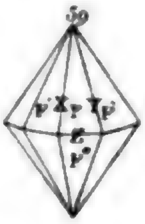

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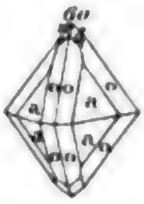

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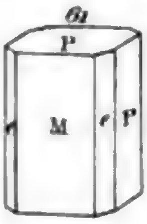

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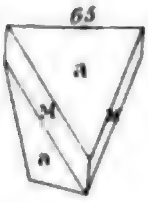

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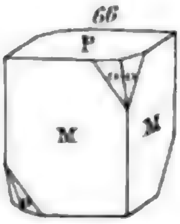

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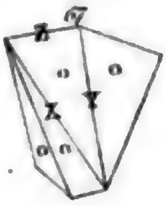

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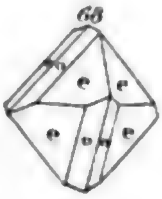


Fig. 1.

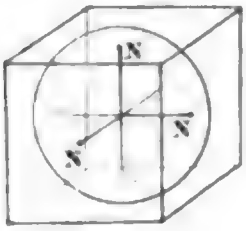


Fig. 2.

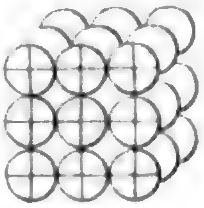
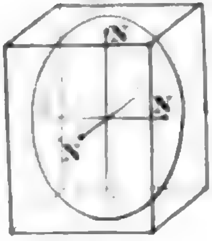


Fig. 3.



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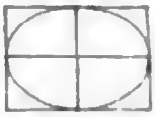


Fig. 5.

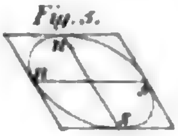


Fig. 7. a.

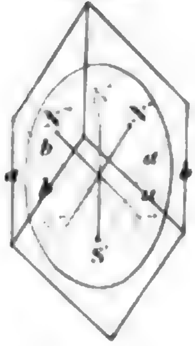
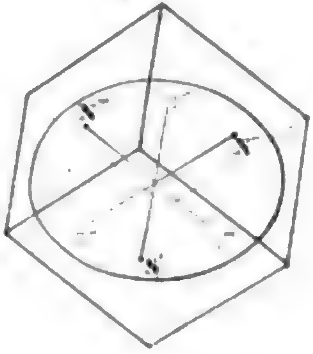


Fig. 7. b.



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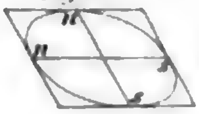

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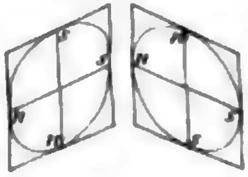

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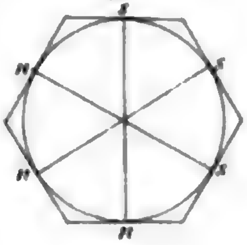

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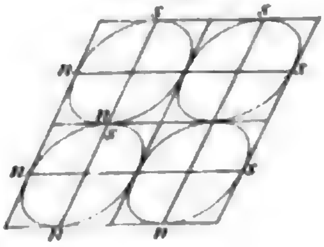

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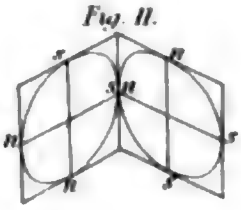

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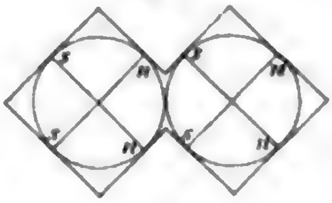


Fig. 13.

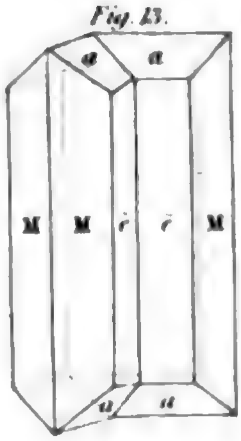


Fig. 13. a.

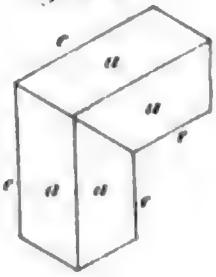


Fig. 13. b.

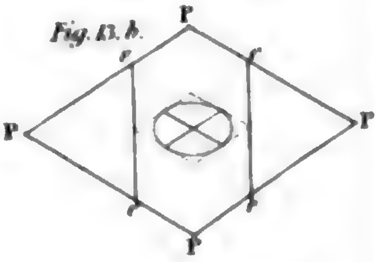


Fig. 14.

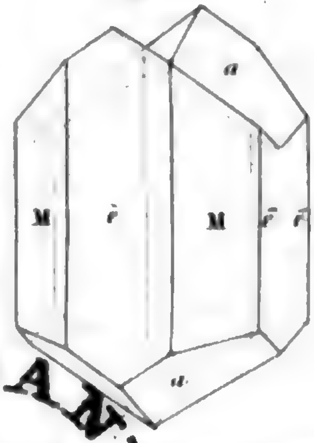


Fig. 15.

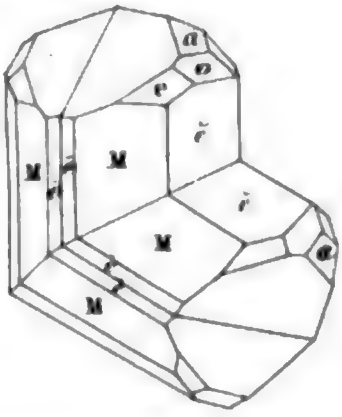
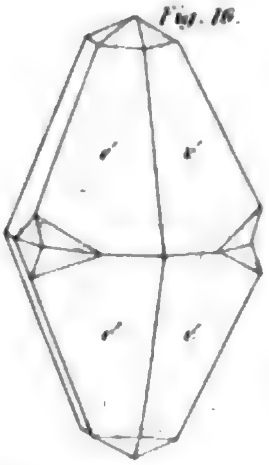


Fig. 16.



G.B. Sherman Sc

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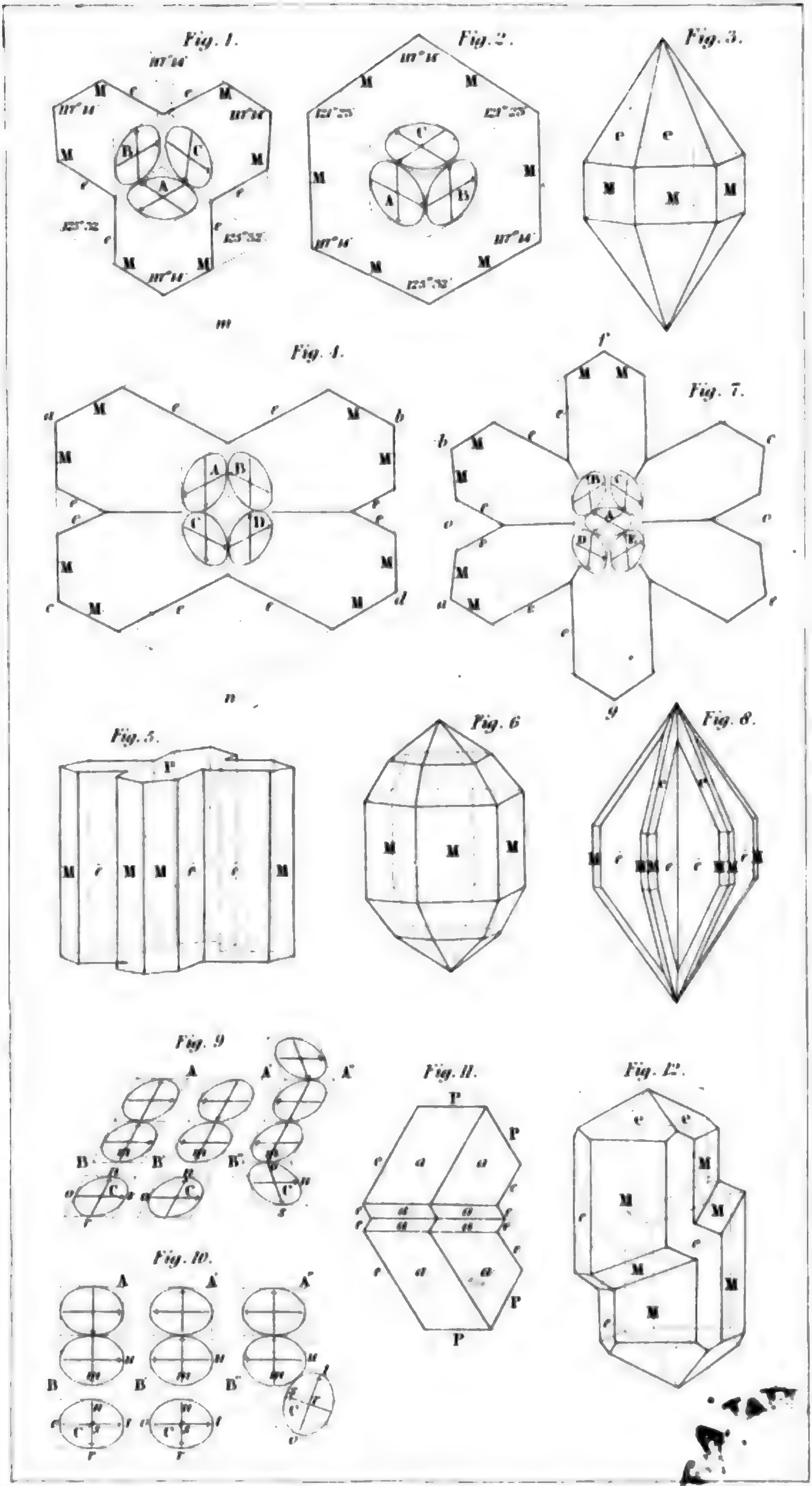
Plate IV.



C. F. Sherman Sc

FORMATION OF TWIN CRYSTALS.